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John Eugene Mauldin
University of Massachusetts Amherst

AUTOSHAPING AND NEGATIVE AUTOMAINTENANCE IN THE BLUE JAY (*CYANOCITTA CRISTATA*), ROBIN (*TURDUS MIGRATORIUS*) AND STARLING (*STURNUS VULGARIS*)

A Dissertation Presented

By

JOHN EUGENE MAULDIN

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Approved as to style and content by:

Dr. Alan C. Kamil, Chairperson of Committee

Dr. John W. Donahoe, Member

Dr. Theodore D. Sargent, Member

Dr. Dalton Miller-Jones, Member

Dr. Charles E. Clifton, Jr.
Acting Chairperson
Department of Psychology

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ABSTRACT

Autoshaping and Negative Automaintenance in the Blue Jay (Cyanocitta cristata), Robin (Turdus migratorius) and Starling (Sturnus vulgaris)

(February 1981)

John E. Mauldin, B.A., Frostburg State College

M.S., Ph.D., University of Massachusetts

Directed by: Dr. Alan C. Kamil

The purpose of the current research was to test the comparative generality of autoshaping and negative automaintenance. Sophisticated procedures and techniques and a variety of dependent measures were used to assess the behavior of three divergent passerine species. Groups of blue jays (Cyanocitta cristata), robins (Turdus migratorius), and starlings (Sturnus vulgaris) were compared in all conditions. A group was exposed to autoshaping and transferred to negative automaintenance. Another group was trained in the reverse order. Different groups were also trained first with one of three associative control conditions and then transferred to autoshaping.

All three species acquired key pecking during autoshaping and each showed a distinctive behavior pattern and stereotyped topography of key pecking. Each species also acquired key pecking during negative automaintenance but none maintained high levels of this behavior. There were systematic behavioral changes, but little key pecking during each of the control conditions. Each group displayed

orderly transfer effects of previous experience during autoshaping and negative automaintenance. Reliable species differences in behavior, key peck performance, and transfer effects were observed during each condition.

A functional interpretation of the consistencies in the behavior of these and other species during these conditions is presented. The relationship of the observed species differences to adaptive specializations of each species is discussed. The theoretical implications of these data and previous research for traditional two process learning theory are reviewed. The adequacy of the biconditional behavior theory to account for these data is evaluated. Several areas where this theory may be extended and refined are suggested. Directions for future research to experimentally test this approach are outlined.

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CHAPTER I

INTRODUCTION

Scope and Purpose

Over the past 10 years considerable research has been conducted in autoshaping and negative automaintenance of the pigeon's key peck response. The results of this research seem to contradict many of the accepted principles of two-process learning theory. While some comparative research has been done in these areas, it has been limited in scope and quality. Often this research has not been comparable to the research with pigeons. The purpose of the current research was to assess the comparative generality and theoretical implications of these phenomena.

The behavior of groups of naive blue jays (Cyanocitta cristata), robins (Turdus migratorius), and starlings (Sturnus vulgaris) was compared during autoshaping, negative automaintenance, and during three control conditions. The transfer relations between these conditions were also explored.

These species were selected because they are representative of three phylogenetically divergent passerine families. They have evolved different behavioral and morphological specializations for feeding but are found in similar habitats and have overlapping ranges. These species may show numerous differences in behavior and key peck

response topography resulting from differences in beak structure, musculature, and species typical feeding behaviors and foraging patterns. These species were also selected because they may be readily obtained, maintained in the laboratory, and successfully employed in behavioral studies.

There has been much parametric research in the areas of autoshaping and negative automaintenance employing pigeons. There has also been several demonstrations of this type of learning using other species. This research has attempted to arrive at a comprehensive understanding of these phenomena. This task is necessary to resolve several problems these phenomena present for traditional interpretations of research in operant and classical conditioning.

In the following sections the conflict between two-process learning theory and auto-phenomena will be summarized. The basic research with pigeons and other species in several major areas will be reviewed. These areas include performance during autoshaping, negative automaintenance, and three associative control conditions, and the response topography of key pecking. A critique of the previous comparative research in these areas will be presented. There will also be a brief overview of the Order Passeriformes and the species under study. There are three major purposes of this literature review:

1. To clarify the theoretical issues raised by autoshaping and negative automaintenance.
2. To provide the rationale for the design, procedures, and the selection of species used in the current research.

3. To establish a context within which to interpret the results of this research.

Two-Process Learning Theory

Traditionally, there have been two basic research paradigms in the field of animal learning. Research in operant conditioning has concentrated on the effects of response-reinforcer relationships on the gross motor behavior of freely moving organisms (Skinner 1938). Research in classical conditioning has been concerned with the effects of stimulus-reinforcer relationships on the reflexive behavior of restrained organisms (Pavlov 1927). This dichotomy has led to a two-process learning theory (Skinner 1938; Kimble 1961; Rescorla and Solomon 1967).

This approach assumes that all conditioned behavior may be classified as either operant or respondent. This classification is based upon the characteristics of the behavior (i.e., voluntary or reflexive) or the procedures used to produce conditioning. It is assumed that respondents are controlled by stimulus-reinforcer contiguities and operants by response-reinforcer contingencies.

Longo, Klempay, and Bitterman (1964) reported classical conditioning of activity in pigeons using an auditory conditioned stimulus. This led to an exchange between Bitterman (1964) and Kimble (1964a,b) which illustrates several major problems of the two-process theory. Kimble (1964a) argued that labeling behavioral phenomena on a procedural basis may result in the inclusion of behaviors with different characteristics and underlying mechanisms in the same category.

Bitterman (1964) pointed out the inherent difficulties of defining behaviors as "voluntary" or "involuntary" without objective criteria. Both agreed that the conditioning procedure couldn't distinguish the underlying mechanism. Kimble (1964b) concluded that no present theoretical system could adequately account for all behavioral phenomena.

Research with Pigeons

Autoshaping. Brown and Jenkins (1968) utilized a similar procedure to that employed by Longo et al. (1964) except that the reinforcement signal or trial stimulus was a brief key illumination. Trial stimulus presentations or trials occurred after variable intertrial intervals (ITI's) and terminated with the delivery of grain reinforcement. The subjects very quickly showed increased activity in the presence of the trial stimulus, but also an orderly "autoshaping" process was observed. This consisted of increases in key orientations very early in training, followed by approaches to the key area and finally, pecks directed at the key. Key pecking was maintained both when it terminated the key stimulus and caused reinforcement delivery and when it had no effect on these events. The results of several control conditions suggested that conditioned key pecking was the result of the association between the stimulus and reinforcement rather than pseudo-conditioning or sensitization effects.

Brown and Jenkins (1968) interpreted these data as resulting from operant reinforcement of key orientations early in training. They were forced, however, to postulate a "species specific tendency

of the pigeon to peck at things it looks at" (p. 70) to account for the changes in approach and pecking behaviors. They noted the procedural similarity to classical conditioning, but termed the phenomenon "autoshaping" because of the complex, voluntary, and directed nature of the conditioned behavior.

This research questions the classification of key pecking as an operant and suggests that traditional interpretations of basic operant phenomena may be inadequate. For example, the "shaping" of key pecking behavior in pigeons could be interpreted as resulting from pairing key orientations with reinforcement. The pigeons' biological predispositions cause the increase in activity, approach, and pecking, rather than the contingency between reinforcement delivery and the emission of successive approximations to the desired response.

This research suggests that recognition of another "type" of behavior with unique properties distinct from the two traditional categories is necessary for the development of a comprehensive learning theory. The best approach is to inductively arrive at a behavioral taxonomy based on the characteristics of the behavior, the controlling procedure, and the effect of parametric manipulations on the conditioned behavior.

Parametric research.

Trial stimulus. In general, it has been found that there is little effect on autoshaping of variations in color and form of the trial stimulus. Autoshaping occurs when the trial stimulus consists of a key light onset, following a darkened ITI, except when the stimu-

lus results in a significant increase in contextual illumination (Brown and Jenkins 1968; Wasserman 1973a; Hemmindinger 1974; Perkins, Beavers, Hancock, Hemmindinger, Hemmindinger, and Ricci 1975). In this case, the localization of the stimulus is degraded. Redundant trial stimulus cues are provided by reflectance of key illumination from various features in the apparatus, which direct pecking away from the key.

When the trial stimulus is key light offset following an illuminated ITI, the acquisition of key pecking is retarded and pecking is also poorly directed (Brown and Jenkins 1968).

Conditioning of activity and pecking may occur with a variety of auditory and visual stimuli. Well directed pecking to the source of auditory cues may be conditioned when these cues are highly localized and consistent with reinforcement delivery cues (Longo et al. 1964; Bilbrey and Winokur 1973; Newlin 1975; Winokur and Boe 1975; Steinhauer, Davol, and Lee 1977).

Temporal factors. Investigations of the effects of the trial stimulus duration, which have held the average ITI duration constant, have typically found that acquisition is most rapid and the rate of autoshaped key pecking is highest when short durations are employed (Brown and Jenkins 1968; Ricci 1973; Baldock 1974; Perkins et al. 1975; Newlin and LoLordo 1973, 1976; Hudiburg and Winokur 1976). Pecking may occur during long trial stimulus presentations, but it is often poorly directed, and pacing and head-bobbing predominate.

Research on the effect of ITI duration, in which the trial stimulus duration has been held constant, has shown that autoshaping

is very poor when ITI durations are short. In general, the rate of acquisition and key pecking increases with increasing ITI values (Newlin and Lolordo 1973, 1976; Baldock 1974; Terrace, Gibbon, Farrell, and Baldock 1975; Perkins et al. 1975; Muller and Cheney 1975; Jenkins and Barnes 1976; Gibbon, Baldock, Locurto, Gold, and Terrace 1977). This effect may be attributed to the tendency of subjects to engage in a great deal of reinforcement magazine orientation and pecking when the interval between trials is short. More importantly, however, these studies have shown that the effect of any trial stimulus or ITI duration is dependent on the relative values or ratio of the two variables. The rate of aquisition and asymptotic rates of key pecking increase as this ratio decreases (Newlin and LoLordo 1973, 1976; Baldock 1974; Perkins et al. 1975; Hudiburg and Winokur 1976; Gibbon et al. 1977).

Negative automaintenance. Williams and Williams (1969) found that several groups of pigeons acquired and maintained intermediate levels of key pecking during trial stimulus presentations although pecking terminated the stimulus and reinforcement was not delivered. These data provide good evidence that stimulus-reinforcer relations are sufficient to elicit and maintain key pecking in pigeons.

Williams and Williams (1969) noted that this phenomenon, termed negative automaintenance, prevented the classification of key pecking as either operant or respondent. It is not an operant because of the failure of the negative response-reinforcer contingency to eliminate the response. It is not a respondent due to the complex,

directed nature of the behavior.

Thus, these data support the notion of a third "type" of behavioral category defined by the properties and effects of parametric manipulations on this behavior.

Parametric research.

Response contingencies. Several studies have compared key pecking during autoshaping and negative automaintenance employing a fixed trial procedure (FT+ and FT- respectively). Key pecking has no effect on trial stimulus offset in both conditions and has no effect on reinforcement delivery during autoshaping. Key pecking during negative automaintenance, however, results in cancellation of the reinforcement delivery. This negative response-reinforcer contingency results in a small decrease in the percentage of trials with a key peck but a much larger reduction in the rate of key pecking relative to performance during autoshaping (Schwartz and Williams 1972; Woodward, Ballinger, and Bitterman 1974).

Schwartz (1972) compared responding during fixed trial negative automaintenance with performance when a variable trial negative automaintenance procedure was employed. In the latter procedure responding caused immediate trial stimulus offset in addition to the cancellation of reinforcement delivery. He found high levels of key pecking during both conditions but the variable trial procedure resulted in a suppression of the percentage of trials with a key peck.

Off-key pecking. Several studies have found very poor maintenance of key pecking during negative automaintenance. Observations

revealed high levels of poorly directed pecks which fail to strike the key. Hursh, Navarick, and Fantino (1974) found that reducing redundant contextual trial stimulus cues increased the percentage of trials with a key peck during variable trial negative automaintenance but high levels of off-key pecking continued to occur.

Barrera (1974) found that most key pecks were forceful and well directed during autoshaping but that only a small proportion of the pecks struck the key during variable trial negative automaintenance. Instead, the birds spent more time in the rear of the chamber and displayed very high rates of idiosyncratic response patterns. They pecked the walls, magazine, ceiling, and floor, and made pecking movements in the air in front of the key.

Similarly, Lucas (1975) observed the occurrence of both key pecks and off-key pecks during autoshaping. During variable trial negative automaintenance key pecking was greatly reduced but off-key pecking increased.

In all the negative automaintenance studies cited so far, only forceful, well-directed pecks which strike and activate the pecking key prevent reinforcement delivery. This may result in the extinction of this type of peck and an adventitious strengthening of weak or poorly directed pecks. Sustained key pecking during negative automaintenance might be attributed to the inconsistent application of the negative contingency for all key directed pecks rather than to an inability of the pigeon to suppress pecking the key stimulus when it results in non-reinforcement.

Wessells (1973) tested this notion by the use of a variable

trial negative automaintenance procedure. In this procedure any "crisp thrusting-forward of the head with the beak aimed directly at the key" (p. 3) during the trial resulted in trial stimulus offset, a brief houselight blackout, and cancellation of the reinforcement delivery. All key pecking was eliminated after a brief acquisition period but stereotyped key orientations and approaches were maintained at high levels. These data are confounded, however, by the potentially aversive effects of response contingent houselight blackout which was crucial to the key peck suppression (Wessells 1974).

Previous experience. Many negative automaintenance studies have failed to control the previous experience of their subjects and there has been little research on the effects of this training on subsequent autoshaping. Barrera (1974) found that a group initially exposed to autoshaping and then transferred to negative automaintenance failed to recover high levels of key pecking when exposed to autoshaping again. He also observed that these subjects maintained positions more distant from the key and displayed more off-key pecking during autoshaping than naive subjects. Similarly, Browne, Peden, and Hearst (1974) found that most subjects initially exposed to a variable trial negative automaintenance procedure failed to acquire high levels of key pecking during autoshaping.

Associative control conditions. Rescorla (1967) described and criticized the traditional control procedures used to assure that classically conditioned responses result from the association or contiguity between the conditioned and unconditioned stimuli. Procedures which

present these stimuli alone were concluded to be inadequate because control subjects are not exposed to all stimuli presented to experimental subjects. Rescorla (1967) suggested the use of a truly random control procedure in which both stimuli are presented randomly and independently. With this procedure there is no predictive relationship between the stimuli, but the subjects are exposed to both under the same temporal parameters as experimental subjects.

Due to the procedural similarity between classical conditioning and autoshaping, Brown and Jenkins (1968) and others have assessed key pecking performance under the control procedures described above. The effects of this experience on autoshaping have also been investigated. This research is important to fully describe the characteristics of this type of behavior and determine how it differs from traditional operants and respondents.

Parametric research.

Trial stimulus alone control. This condition consists of a number of sessions in which the key light stimulus is presented as in normal autoshaping, but reinforcement is never delivered. Research with a wide range of pre-exposure parameters has found no tendency for the subjects to approach, withdraw, or peck the key and no transfer effects during autoshaping (Brown and Jenkins 1968; Gamzu and Williams 1973; Bilbrey and Winokur 1973; Wasserman, Franklin, and Hearst 1974; Wasserman and Molina 1975).

Reinforcement alone control. This procedure is also similar to normal autoshaping except that the key light stimulus is never

presented. No tendency for the subjects to peck the key has been demonstrated. Brown and Jenkins (1968) observed idiosyncratic "superstitious" behavior patterns during this condition.

Endberg, Hansen, Welker, and Thomas (1972) found a significant retardation of key peck acquisition after extensive reinforcement alone training. These data were criticized by Gamzu, Williams, and Schwartz (1973) as the statistical analyses were questionable and the criterion of key peck acquisition did not reflect asymptotic responding.

Schwartz, Reisberg, and Vollmecke (1974) failed to observe any retardation of key peck acquisition after extensive reinforcement alone training. There was, however, a reliable reduction in the percentage of trials with a key peck and the rate of key pecking compared to a group given no pre-exposure.

Random trial stimulus-reinforcement control. In this procedure both the trial stimulus and reinforcement are presented according to normal autoshaping parameters. They are controlled by independent schedules, however, such that there is no predictive relationship between the two events. The results of research on the effects of this training have been remarkably consistent despite numerous procedural differences. In all cases little key pecking was observed during pre-exposure. There was, however, a permanent retardation of acquisition and asymptotic rates of key pecking during autoshaping (Gamzu and Williams 1971; Bilbrey and Winokur 1973; Wasserman et al. 1974; Tomie 1976a,b).

Wasserman et al. (1974) observed no active approach or

avoidance of the key by the subjects during this condition. During autoshaping the subjects' tendency to approach the key increased only slightly and key peck acquisition was poor.

Pecking response topography. Wolin (1948) observed differences in the response topographies shown by pigeons during normal feeding and drinking activities. He compared these response patterns to those shown by different groups key pecking for food and water reinforcement in an operant situation. Topographical differences were also noted between these two response patterns, which were similar to those shown during consumption of the reinforcers. Wolin interpreted these data as evidence that the properties of operant responses are determined by both the response-reinforcer contingency and the type of response normally elicited by the drive state involved.

Breland and Breland (1961) found it difficult to maintain certain operant responses due to the intrusion of species typical behavior patterns normally associated with the ingestion of the reinforcer. The subjects failed to perform the appropriate responses and consistently lost a high percentage of the reinforcers. They interpreted these data as indicating that animals are often predisposed to behave in certain ways in the presence of stimuli correlated with different reinforcers. This tendency is stronger than the tendency to perform the desired operant response which results from the response-reinforcer contingency.

The interpretations of these phenomena are similar to those proposed to account for autoshaping and negative automaintenance

(Brown and Jenkins 1968; Williams and Williams 1969). These approaches assume a biological predisposition to behave differently in the same situation when different reinforcers are employed. These data have important implications for traditional assumptions regarding the "arbitrary" nature of the pigeons' key peck response and its definition as an operant. These data also show that the type of reinforcement used in an operant situation may have important effects on the performance and topographical characteristics of the behavior under study.

Parametric research.

Food vs. water reinforcement. Jenkins and Moore (1973) conducted an extensive analysis of the response topographies shown by pigeons during autoshaping with food and water reinforcement. They found that either the subjects failed to autoshape with water reinforcement or they performed very poorly compared to the food reinforcement group. Key peck topographies in the two groups were clearly different and replicated those reported by Wolin (1948). Jenkins and Moore also demonstrated that the rate of key pecking and the response topography was determined by the reinforcer paired with the trial stimulus during autoshaping rather than the current deprivation state or the reinforcement available in the situation.

Woodruff and Williams (1976) found rapid autoshaping with a procedure employing water reinforcement injected through a cannula attached to the bird's beak. Pecking rates varied from intermediate to high levels and pecking occurred on most trials. All subjects

acquired key pecking during negative automaintenance but performance was poor and off-key pecking was observed. During both conditions each subject acquired high rates of a similar behavior pattern. This behavior pattern conformed to the descriptions provided by Craig (1912) of the complete species-specific drinking pattern in pigeons. This pattern included "bowing," "rooting," "mumbling," and "swallowing" behaviors. These data extend the observations of Jenkins and Moore (1973) to include a complex species typical "rooting" pattern displayed during normal drinking and prior to and during contact with the key.

Morrison (1974) examined the relationship between pecking, "bowing," and "rooting" behaviors in a negative automaintenance procedure with water reinforcement. He found that key pecking during the trial stimulus presentations was acquired but decreased rapidly and was replaced by "bowing" and "rooting." When a negative contingency was instituted for the occurrence of any two of these responses during the trials the rates of those responses decreased to low levels but the rate of the other response increased to high levels. When a negative contingency was instituted for occurrences of all three behaviors during the trials, all three responses were maintained, resulting in the loss of most of the reinforcers. When these subjects were tested under negative automaintenance with food reinforcement, it was found that more key pecking occurred than with water reinforcement. More reinforcers were lost, however, in the latter condition when the occurrence of any of the three behaviors prevented reinforcement delivery.

These data provide evidence that the pigeons' motor response systems for eating and drinking differ substantially. These differences include the components of the behavior pattern displayed prior to emission of the pecking response, the topography of the pecking response, and the effect of a negative contingency on the occurrence of this response.

The behavior pattern displayed prior to eating consists of orientation and approach components. The effect of a negative contingency on pecking is to reduce both the frequency and probability of the occurrence of the response. The behavior pattern displayed prior to drinking, however, consists of a more complex pattern of responses which also includes orientation and approach behaviors. The effect of a negative contingency on pecking is to eliminate this response but the other components are substituted and maintained at a high rate. The effect of a negative contingency on any single or pair of these components is to increase the rate of the remaining response(s).

Thus, it seems reasonable to assume that these three components in the drinking system are functionally equivalent to the pecking response in the feeding system. That is, in the feeding system, orientation and approach are invariably followed by pecking. In the drinking system "rooting," "bowing," or pecking may each occur separately or in combination, depending on the prevailing response-reinforcer contingencies.

This research suggests that the pigeon has evolved two response systems associated with feeding and drinking. These systems differ in complexity and topography and cause a predisposition to

respond differentially to stimuli associated with these two reinforcers. This raises the possibility that divergent species will show differences in performance and response topography during autoshaping and negative automaintenance. These differences would be due to evolved differences in the feeding response systems related to specializations in feeding behaviors and foraging patterns.

Comparative Research

A variety of different species have been trained using procedures similar to those employed by Brown and Jenkins (1968). These experiments have demonstrated conditioning of several kinds of responses using various types of stimuli and reinforcers. These data establish the broad comparative generality of autoshaping and to a lesser degree that of negative automaintenance.

Key striking behavior in several species of fish has been conditioned using food reinforcers (Squier 1969; Woodard and Bitterman 1974; Waxman and McCleave 1975). Respondent conditioning of aggressive display by Siamese fighting fish is a well established phenomenon (Adler and Hogan 1963; Thompson and Sturm 1965; Thompson 1966).

A number of studies have been reported utilizing avian species and non-traditional reinforcers. Farris (1967) demonstrated respondent conditioning of courting behavior to a key light stimulus in Japanese quail. Gilbertson (1975) autoshaped key pecking in male pigeons with access to a female as the reinforcement. The acquisition of key pecking in young chickens utilizing heat reinforcement has been

investigated in a number of studies (Zolman & Martin 1967; Zolman 1968, 1969; Zolman, Chandler and Black 1971; Wasserman 1973; Wasserman, Hunter, Gutowski, and Bader 1975).

Bar pressing in several mammalian species has also been autoshaped. Numerous studies have been reported using rats and food reinforcement (Powell, Saunders, and Thompson 1968; Davidson, Davis, and Cook 1971; Ponicki 1974; Davenport 1974; Myer and Hull 1974). Smith and Smith (1971a,b) autoshaped dogs with food reinforcement. Several studies have demonstrated autoshaping in primates (Sidman and Fletcher 1968; Gamzu and Schwamm 1973, 1974; LIkely 1974).

A few studies have reported low sustained rates of bar press responding during negative automaintenance using rats (Stiers and Silberberg 1974; Hardy, Hochstette, and Parker 1974). Gamzu and Schwamm (1973, 1974) found, however, that squirrel monkeys failed to maintain key panel responding under variable trial negative automaintenance conditions.

These data indicate that it is possible to condition a wide variety of response patterns in different species using the autoshaping procedure. The comparative generality of negative automaintenance is also supported to some extent, but due to the paucity of data it is difficult to draw any firm conclusions on this issue.

Comparative research with avian species.

The bobwhite quail. Gardner (1969a) found that bobwhite quail (Colinus virginians) rapidly acquired key pecking during autoshaping. Observations indicated that all subjects developed a stereotyped beha-

vior pattern during trial stimulus presentations. This pattern consisted of rapid alternations between scratching the floor and walls and pecking the key at a high rate. The key was pecked with a widely opened beak and they often bit the edge of the key aperture.

Gardner (1969b) found that autoshaping experienced bobwhite quail showed a substantial reduction in the rate of key pecking following transfer to negative automaintenance. Responding, however, was maintained at a low level.

These data demonstrate many similarities between the performance of pigeons and bobwhite quail during autoshaping and negative automaintenance. However, there are clear species differences in the response topography of key pecking. In addition, scratching is a behavioral component in the feeding response system of the bobwhite quail but not in that of the pigeon.

The crow. Powell, Kelly, and Santisteban (1975) found very poor autoshaping in crows (Corvus brachyrynchos). Some subjects acquired key pecking but only one subject maintained responding across several sessions. Subjects which had failed to autoshape were later hand shaped to key peck and performed on a continuous reinforcement schedule but gradually stopped pecking when transferred back to autoshaping.

Powell et al. (1975) tested a group of fish crows (Corvus ossifragus) using a variable trial autoshaping procedure. Only one subject showed any reliable autoshaped key pecking but this was eliminated following transfer to a fixed trial procedure. Informal behavioral observations did not reveal any consistent patterns during

trials or ITI's and most subjects seemed to ignore the trial stimulus presentations.

Powell et al. (1975) concluded that autoshaping was an ineffective procedure for engendering or maintaining key pecking in the crow. In previous research it was demonstrated, however, that they perform similarly to pigeons on various schedules of reinforcement (Powell 1972, 1973). They attributed the failure to autoshape to differences between the feeding behaviors of the two species. Crows are omnivorous feeders who prefer live prey and display a very different foraging pattern from pigeons. Pigeons forage by pecking rapidly over a relatively large area to obtain small bits of grain and seeds. Crows search for larger prey and peck much less frequently, thus requiring more sensitivity to the outcome of each peck. This explanation would limit the importance of autoshaping and would restrict its effectiveness to situations in which the response is emitted frequently during species typical feeding or other response patterns.

Powell and Kelly (1976) found that groups of crows and pigeons which had been operantly conditioned to key peck and pigeons with previous operant schedule experience maintained key pecking during a response dependent procedure. This procedure was similar to autoshaping except the reinforcement was delivered only if a key peck occurred during the trial stimulus presentation. When they were transferred to a variable trial negative automaintenance condition, the crows rapidly learned to withhold key pecking during trials. The naive pigeons also showed a rapid decrease in key pecking, but lost more reinforcers per session than the crows. The experienced pigeons

performed much differently, however, requiring many more sessions to reduce performance. These data indicate another difference between the performance of pigeons and crows and emphasize the effect of previous experience on behavior during negative automaintenance.

These data demonstrate that there are substantial differences between the performance of pigeons and crows during autoshaping and negative automaintenance. The crows show much less sensitivity to stimulus-reinforcer relationships and more sensitivity to response-reinforcer relationships. These differences may be based on species differences in foraging patterns and feeding behaviors.

Critique of Comparative Research

This research suggests that species which show differences in foraging patterns and feeding behaviors will display differences in behavior and performance during autoshaping and negative automaintenance. There are, however, many procedural differences between these comparative studies and the research done with the pigeons. These differences limit the comparisons which may be made between the results of these experiments.

There has been a limited number of comparative studies, and most have used only a single species. Overall, only a few species have been tested. None have employed a comprehensive set of dependent variables and training conditions or sophisticated procedural techniques. Species selection has been based primarily on convenience. Little effort has been made to utilize the existing literature on the

natural behavior of these species to account for observed species differences.

Naturalistic Research on the Species Under Study

Hinde (1971) characterized the avian group as having both a large, complex repertoire of fixed action patterns and a broad capacity for learning. There is marked adaptive radiation in this group with families often showing substantial divergence in these characteristics. The feeding behaviors and foraging strategies of avian species are frequently species-typical, usually consisting of a number of easily identifiable motor patterns. Hinde emphasized, however, that even closely related species may differ substantially in the initial reactions to releasing stimuli and in the extent to which learning is involved in the acquisition or development of these behavior patterns. The reactivity to eliciting stimuli often varies more between species than the characteristics of the response pattern displayed.

The order Passeriformes and the species under study. There has been substantial research on the morphological and behavioral characteristics of many species in the order Passeriformes. Providing a systematic classification of this group, however, has proven extremely difficult. Mayr and Amadon (1951) reviewed this information and proposed a classification system based on a linear rather than a branching sequence. They pointed out, however, that the concept of a continuum of increasing specialization was meaningless with this group

due to the diversity and highly specialized nature of most extant species. They placed ancestral groups first and related groups close together in this system using the traditional numerical sequence of orders, suborders, families and subfamilies.

In this system the Columbidae, of which the pigeon is a member, is older than the Passeres. The three species employed in the current research are all members of the order Passeriformes and the suborder Oscines, the Song Birds. This large group is characterized as the most successful and newest suborder. It shows an "umbrella" type phylogenetic tree with much diversity, specialization, and parallelism between families and subfamilies.

The blue jay is a member of the family Corvidae which is made up primarily of crows and Australian crowlike birds. This family is characterized as a monophyletic group of closely related genera with the Cyanocitta being one of the oldest extant groups. Amadon (1944) placed this group near the center of the diversified phylogeny of the Corvidae. This indicates some advancement and specialization over the oldest genera, but the group also possesses many of the common characteristics of the family.

The robin is a member of the Old World Insect Eaters or family Muscicapidea and a member of the subfamily Turdidae, commonly called thrushes. This group is large and difficult to classify but is characterized as a natural group not closely related to other subfamilies.

The starling is a member of the family Sturnidae consisting of the weaverbirds and similar species. Amadon (1943, 1956) placed

the Sturnus genus in the center of the phylogeny of the Sturnidae. This indicates the presence of many characteristics common to the family but also advancement over the oldest predecessors of this group.

General Summary

This study was designed to avoid the criticisms of previous comparative research, outlined above. Three passerine species were compared to determine whether differences exist in the behavioral patterns and topography of responses during each experimental and control condition. These species were selected because they show differences in feeding behaviors and foraging patterns and due to availability and previous success in conducting behavioral research with these species. Naive subjects were employed to avoid transfer effects from previous experience.

The procedures, parameters, and apparatus employed in the current research were selected as the most reliable for initiating and maintaining autoshaped key peck responding in pigeons and other species.

The experimental design assessed the behavior of each species during autoshaping, negative automaintenance, and three control conditions. This design also allowed analysis of the effects of previous experience on behavior during autoshaping and negative automaintenance.

The observational techniques allowed a quantitative analysis of each species' behavior and pecking topography. These techniques

also allowed the detection of off-key pecking and prevented the adventitious reinforcement of these responses during negative automaintenance. A variety of dependent measures were employed which have been frequently used in previous research.

CHAPTER II

METHOD

Subjects

Thirty-six naive subjects were employed: 12 blue jays (Cyanocitta cristata), 12 robins (Turdus migratorius), and 12 starlings (Sturnus vulgaris). Two of the robins were dropped from the study. One failed to habituate to the apparatus and one failed to magazine train.

All subjects were obtained in the Amherst, Massachusetts area when 8-12 days old and were hand-reared in the laboratory. The subjects were between 14 and 26 months old at the time of training.

Apparatus

Operant chamber. A modified Lehigh Valley Electronics operant chamber was employed containing a subject cubicle measuring 33 x 30.5 x 35.5 cm high. The chamber contained two false ceilings mounted in sliding tracks, a removable false floor, a reinforcement magazine, and a pecking key.

The interior of the subject cubicle was painted a uniform white. All mounting screws were countersunk and puttied. The cubicle was brightly illuminated and the trial stimulus consisted of a dim light. These procedures were employed to minimize redundant contextual cues and environmental features (i.e., screw heads) in the sub-

ject cubicle which might direct pecking.

Similar lights were used for the key stimulus and reinforcement delivery signal. These lights provided consistent reinforcement magazine and trial stimulus cues.

The upper false ceiling was a 32 x 29.5 cm piece of .25 cm thick Masonite located 2.54 cm below the chamber ceiling. A speaker was mounted in the center and a triangular bank of three 120v (D18-C-7 1/2) white Christmas tree bulbs was mounted in each corner. The speaker and a ventilation fan provided masking noise (80 db) during all sessions. The Christmas tree bulbs provided bright, evenly distributed illumination of the subject cubicle.

The second false ceiling was a 32 x 29.5 cm piece of translucent Plexiglass mounted 3.75 cm below the first false ceiling. This ceiling disbursed the illumination provided by the Christmas tree bulbs and prevented the subjects from having access to these lights or the speaker.

The false floor was a 32 x 29.5 cm piece of 1.88 cm thick wallboard. A piece of .25 cm thick Masonite secured a sheet of thin wire mesh to the surface of the floor. This floor provided a surface upon which the subjects could walk without slipping and it elevated the subjects such that the pecking key was at eye level for all three species.

The reinforcement magazine was mounted on the lower right side of the front wall 6.88 cm from the false floor and 7.2 cm from the door. It consisted of a 4.6 x 3.1 cm aperture with a rectangular food cup protruding 1.25 cm from the wall. A 12v reinforcement deli-

very light was mounted on the back side of the chamber wall, inside the food cup, but above the aperture.

The translucent Lehigh Valley pecking key was centrally mounted on the back side of the front wall with the center of the pecking panel located 18.88 cm from the chamber floor and 17.78 cm from the door and the side wall. A 2.54 cm diameter hole was cut in the wall located at the center of the pecking panel. This panel was constructed of .16 cm thick Plexiglass. A round .32 cm thick Plexiglass plug (2.54 cm diameter) was attached to the center of the panel. This plug made the key surface flush with the interior cubicle wall. An IEE multiple stimulus projector, containing 12 12v lights, was mounted directly behind the center of the pecking panel.

The door of this chamber was constructed of .64 cm thick Plexiglass and was 33.02 x 40.01 cm high. It was equipped with hinges mounted to the rear chamber wall. A set of clamps mounted on the back side of the front wall secured the door tightly against the chamber walls. A thin sheet of white metal measuring 33.02 x 40.01 cm high was attached to the interior surface of this door. A 15.24 x 25.4 cm wide viewing window was cut in this metal sheet 12.7 cm from the false floor and 3.81 cm from the front and rear walls. A piece of fine wire mesh was painted white and inserted between the metal sheet and the Plexiglass. This door provided substantial visual isolation of the subject cubicle from external stimuli and minimized the reflection of interior images off the viewing window.

Computer system. A Lehigh Valley Electronics INTERACT computer system, located in an adjacent room, was used to control all stimulus

presentations, response contingencies, the delivery of reinforcements, and to record the data.

Input to this system for behavioral scoring was provided by key closures in the subject cubicle and by seven push buttons mounted on a 16.5 x 11.43 cm Masonite scoring panel operated from the computer room. Two additional push buttons on this panel were used to control program execution and termination and to signal the computer that reinforcement had been retrieved by the subject.

Videotape system. During all sessions formal behavioral observations were carried out employing a Sony videotape system. A videocamera, equipped with a zoom lens and tripod, was positioned approximately 100 cm from the viewing window in the chamber door. An f-25 low impedance microphone was mounted in the chamber on the back side of the front wall, near the reinforcement magazine. This microphone was used to monitor sounds produced by the subjects during the sessions. A second microphone was used in the computer room to provide verbal identification and description of sequences recorded during the sessions. A color videorecorder in the computer room was used to record sequences on Sony and Memorex 1/2 inch videotape. A color videomonitor with a 10 x 14 inch screen, also in the computer room, was used to observe the subjects during all sessions. This system provided a full view of the interior of the subject cubicle from front to rear and floor to ceiling.

Photography system. A Bealieu 4008 ZM II super-eight movie camera was used to photograph typical behavior patterns during selected

sessions. This camera, equipped with a zoom lens and tripod, was positioned approximately 120 cm from the viewing window in the chamber door. The angle of view, speed of filming, and the degree of zoom varied depending on the situation. In general, speeds of 24-48 fps were employed, and the camera was tightly focused on the key and surrounding area.

Procedure

Experimental design. Two experimental and three control conditions were employed in the study. A number of subjects of each species were randomly assigned to one of five groups. After pretraining, each group was trained on one of the experimental or control conditions and then transferred to one of the experimental conditions. Table 1 summarizes the overall experimental design of the study. This experimental design allowed assessment of the reaction of each species to each condition. The transfer procedure allowed analysis of the effects of each type of training on later learning.

Observational techniques.

Behavioral scoring. During all sessions formal behavioral scoring was conducted. The frequencies of the following behaviors were recorded:

Key peck-A peck to the key with sufficient force to operate the microswitch.

Off-key peck-A topographically similar peck to the key which was poorly directed and/or did not have sufficient force to operate

Table 1

Experimental design for the study indicating the type of condition, group number, number of subjects per species in each group, and the conditions presented to each group during Stages I and II.

Group Number	Number of S's/Species	Stage I	Stage II
Experimental Conditions			
I	3	Autoshaping	Negative Automaintenance
II	3	Negative Automaintenance	Autoshaping
Control Conditions			
III	2	Trial stimulus alone	Autoshaping
IV	*2	Reinforcement alone	Autoshaping
V	*2	Random trial stimulus-reinforcement	Autoshaping

* Indicates only one robin included in this condition.

the microswitch.

Magazine peck-A peck to the reinforcement magazine.

Peck wall-floor-A peck to any other interior surface of the subject cubicle.

Orient key-An orientation of the bird's beak to the key aperture.

Orient magazine-An orientation of the bird's beak to the reinforcement magazine.

Approach key-Any movement toward the key wall.

Away key-Any movement away from the key wall.

The frequency of these behaviors were recorded as discrete events. Multiple occurrences of a behavior were separated by the observation of a different behavior. This intervening behavior did not, however, have to fall in the categories being scored.

The frequencies of the key peck and off-key peck responses were combined in all data analyses, figures, and tables.

This procedure allowed analysis of the relative rates of eight behaviors during each session of training on each condition. In addition, it insured that all key directed pecks canceled reinforcement delivery during negative automaintenance.

Behavioral scoring reliability. The habituation session for pilot subjects of each species was recorded on videotape. By synchronizing the beginning of these tapes with the onset of behavioral scoring it was possible to later re-score these tapes. These tapes were re-scored by the experimenter until the following scoring reliability criteria were met:

1. The percentage agreement between ten trial summary frequencies recorded during two successive scoring sessions with the same tape exceeded 90% over all behaviors scored.
2. The Pearson Product Moment Correlation Coefficient between ten trial summary frequencies recorded during two successive scoring sessions with the same tape exceeded .9 over all behaviors scored.

After these criteria were met, the experimenter trained another observer in the behavioral scoring techniques. This observer practiced scoring the pilot tapes until the above criteria were met between data recorded by the experimenter and the observer scoring the same tape.

At regular intervals during the study the habituation session for one randomly selected subject of each species from the autoshaping and the negative automaintenance groups was videotaped. The tapes were then re-scored by the experimenter and the trained observer. These data were compared with the data recorded during the session to assure that the scoring reliability for each behavior continued to exceed the above criteria.

It was possible to analyze behavioral scoring reliability during habituation sessions because the scoring trials were a fixed 60 second duration. It was not possible to analyze scoring reliability during the other conditions because the order of ITI durations were randomized during each session and it was not possible to replicate the order of ITI's used in any particular session.

Videotape recording. During all sessions the videorecorder was set on the "pause" mode. Representative sequences of behavioral patterns and response topographies displayed by each subject during acquisition, stable performance, and transfer performance on each condition were recorded. These tapes were viewed at both normal and slow speeds to analyze and compare response topographies and behavioral patterns displayed by individuals within and between groups and species.

Super-eight movie photography. During acquisition and stable performance of each subject in each condition, short film sequences were made of the typical behavior patterns and key peck response topographies. This was accomplished by adjusting the focus and zoom settings on the camera prior to the session. The camera was activated by a remote control switch when the behavior of interest occurred during the session.

One subject from each species was selected at random from the autoshaping and negative automaintenance groups. Short sequences of its behavior were photographed during each session of acquisition, stable performance, and transfer performance.

These films were edited and utilized in normal and slow speed analysis of the behavior patterns and response topographies shown by each species during each condition. These films were also used to produce a formal film presentation illustrating the development of the typical behavior patterns and response topographies of each species during each condition.

Deprivation schedule. A mean free feeding weight was determined for each subject over a five day period. The subjects were handled daily and hand fed meal worms (Tenebrio larvae) to facilitate adaptation to the training procedures. During the next 7-10 days, they were reduced to 80% ad lib weight by successively decreasing the amount of food available each day in the home cage. They were maintained on this deprivation schedule during pretraining and training.

Pretraining.

Habituation. After each subject had remained stable at 80% ad lib weight for at least 3 days, an habituation session was conducted. This session began by placing the subject in the apparatus and observing its behavior until exploration of the cubicle began. Locomotor activity usually commenced immediately, but in some cases the subject froze in one position for 60 minutes or longer. One robin was eliminated from the study because it failed to show any locomotor activity during 5 daily sessions in the chamber.

Five minutes after locomotor activity commenced the computer was activated and behavioral scoring began. In certain cases the videorecorder was used to record the entire session for later analysis of behavioral scoring reliability.

The computer first printed out identifying information on the subject. The frequencies of each of the behaviors being scored during each minute or trial were printed out at the end of each trial. After 60 trials had been presented, a buzzer sounded and the cumulative frequencies of each behavior during the session were printed out along

with additional identifying information.

The subject was immediately removed from the apparatus and placed in the home cage. The daily feeding following this and all sessions occurred after a variable interval, between 30-60 minutes. This procedure maintained motivation during the session by preventing the expectation of immediate access to food at the end of the session.

Magazine training. On the following day a magazine training session was conducted. This session consisted of placing the subject in the apparatus and observing until exploration of the cubicle began. The computer was activated 5 minutes later and behavioral scoring began. The scoring procedure was the same as that used during the habituation session. A reinforcement delivery and 1 second food cup illumination occurred randomly with a probability of .5 at the end of each one minute scoring trial. When a reinforcer was delivered, the scoring trial duration was extended until the subject retrieved the reinforcement. Retrieval of the reinforcement was recorded by depressing a button on the scoring panel.

The subjects' latency to retrieve the reinforcer was recorded automatically. The number of consecutive reinforced trials on which this latency was less than four seconds was accumulated. When the subject met this latency criterion on 5 consecutive reinforced trials a summary of the overall cumulative frequencies across the session of each behavior being scored was printed out.

Thirty more one minute trials were then scored and the cumulative frequencies were printed out but no more reinforcers were delivered. The subject was then removed from the apparatus, placed in

the home cage, and fed later. This procedure allowed analysis of the effects of magazine training on behavior.

If the subject failed to meet the latency criterion within 60 trials the session was terminated and similar sessions were conducted on the following days until criterion was met. This criterion was not met within five sessions by one robin and it was eliminated from the study.

Training.

Standard procedures. Daily 50 trial sessions, lasting approximately 60 minutes, were presented during each experimental and control condition. This schedule provided a large number of observations each day without requiring the subjects to remain in the apparatus for an excessive period of time. This schedule also provided a sufficient amount of reinforcement to significantly reduce the subjects' deprivation level without reaching the point of satiation.

The temporal parameters employed in each condition have been used in a large number of experiments. These parameters typically result in reliable autoshaping of key pecking in pigeons.

A fixed trial procedure was employed in all conditions to avoid response-suppression from contingent trial stimulus offset. This procedure also allowed analysis of both the rate of key pecking and the percentage of trials with a key peck.

Four to eight subjects were tested each day. The overall order of training was random with respect to group and species. The time of training each day for each subject was determined by the

birds' relative dgree of deprivation. Those subjects which were at or below their 80% ad lib weight were trained first. Those subjects above their 80% ad lib weight were trained later in the day, after their weights had dropped.

Experimental conditions. Daily sessions were presented of each experimental condition until the rates, during both trials and ITI's, of all 8 behaviors being scored met one of the following stability criteria:

1. Each behavior was considered stable when the standard deviation was less than or equal to 10% of the mean rate for that behavior over the previous five sessions.
2. Each behavior was considered stable when the rate remained less than or equal to two responses per minute for five consecutive sessions.

This procedure provided a large number of exposures to the stimulus- and response-reinforcer contingencies employed in these conditions. The stability criteria insured that each subject had reached asymptotic performance and was engaging in a stable pattern of behavior. This approach allowed analysis of the reactions of each subject to each condition without the confounding of differential degrees of behavioral stability between subjects. This confounding would have occurred if the subjects had been exposed to a fixed number of training sessions during each condition.

Autoshaping (FT+). On the day following magazine training the first session of autoshaping was conducted. All sessions consisted of placing the subject in the apparatus and observing until

locomotor activity began. The computer was then activated, identifying information on the subject was printed out and behavioral scoring began.

The computer sequentially scanned one of five randomly ordered lists of the following ten ITI durations suggested by Fleshler and Hoffman (1963):

7.85 sec	37.95 sec	81.62 sec
13.97 sec	49.03 sec	110.40 sec
20.86 sec	62.93 sec	186.64 sec
28.75 sec		

The probability that each of these ITI durations would be selected was equal and scanning continued until one was selected. The five different lists were alternated randomly during every five sessons to insure an unpredictable sequencing of the ITI durations.

After the first ITI duration was selected, the computer timed this interval. Then a 10 second trial stimulus presentation occurred, consisting of illumination of the pecking key by a plain white stimulus projection. At trial stimulus offset, a reinforcement was delivered to the food cup which was illuminated for 1 second.

Behavioral scoring continued uninterrupted throughout the trial stimulus presentation, the reinforcement delivery, and the period before the subject retrieved the reinforcement. Retrieval of the reinforcement was recorded by depressing a button on the scoring panel. The sequence of events from trial stimulus onset until the subject retrieved the reinforcement defined a trial under this condition. Then another ITI duration was selected at random, beha-

vioral scoring continued uninterrupted, and the sequence of events described above was repeated until 50 trials were presented.

After each ITI duration was selected the probability that the same duration would be selected again was zero. After each ITI duration had been selected once, the probabilities were reset and the entire list was scanned in selecting the next ITI duration. This procedure resulted in the presentation of a 10 second trial stimulus-reinforcement pairing on a random, variable interval, 60 second schedule, independent of the subject's behavior.

After 50 trials were presented a buzzer sounded. The overall cumulative frequencies of each behavior being scored and the durations of all trials and ITI's were printed out. The subject was then removed from the apparatus, placed in the home cage, and fed later.

Negative automaintenance (FT-). All procedures were identical to those during autoshaping except that a key peck or an off-key peck during a trial canceled the reinforcement delivery for that trial.

To allow direct comparison with the other conditons, behavioral scoring on non-reinforced trials continued beyond trial stimulus offset. This period consisted of the 1 second reinforcement delivery duration plus the latency to retrieve reinforcement recorded after the last reinforced trial. This procedure resulted in the inclusion of the subject's reaction to trial stimulus offset without reinforcement delivery during scoring of that trial rather than the next ITI. This was consistent with the procedure used when reinforcement was delivered during autoshaping or on a negative automaintenance trial when

no key peck was emitted.

Control conditions. Ten daily 50 trial sessions of each control condition were presented to each group. This procedure provided a large number of exposures to the stimulus presentations and/or reinforcement deliveries during each condition. Initial pilot work indicated that behavioral stability was attained rapidly during these conditions, usually within 5-8 sessions. Training the subjects for a fixed number of sessions equalized exposure to the different events during each condition. This approach allowed comparison of the reaction of each individual to each condition and the effects on later autoshaping without the confounding of differing amounts of exposure to this training. This confounding would have occurred if each subject had been required to attain behavior stability during each condition. Subsequent analysis indicated that behavoral stability was attained by most subjects during each condition.

Trial stimulus alone (TS). All procedures were identical to those during autoshaping except that reinforcement was not delivered at trial stimulus offset.

To allow direct comparison with the other conditions, behavioral scoring during trials continued beyond trial stimulus offset. This period consisted of the 1 second reinforcement delivery duration plus the average latency to retrieve reinforcement displayed by all subjects of that species which had been previously tested in all conditions.

Reinforcement alone (SR). All procedures were identical to those during autoshaping except that the key light stimulus was not

presented prior to reinforcement delivery. Behavior scoring was exactly as in the autoshaping condition.

Random trial stimulus-reinforcement (TS-SR). All procedures were identical to those during autoshaping except that the delivery of reinforcements was independent of trial stimulus presentations. The interreinforcement interval was determined by a separate response independent, random, variable interval, 70 second schedule from that which determined the presentation of trial stimuli.

To allow direct comparison with the other conditions behavioral scoring during trials continued beyond trial stimulus offset. This period consisted of the 1 second reinforcement delivery duration plus the duration of the latency to retrieve reinforcement recorded after the last reinforcement delivery.

The interval from the last trial stimulus onset to the next reinforcement delivery, and from the last reinforcement delivery to the next trial stimulus onset were recorded. These data were printed out at the end of the session along with the individual trial and ITI duration data. This information was used to assure that there was no empirical relationship between trial stimulus presentations and reinforcement deliveries during this training.

CHAPTER III

RESULTS

Organization and Dependent Measures

This section summarizes the organization of the chapter and describes the dependent measures and statistics employed. The next two sections present the behavior of each species in each of the two experimental and three control groups in the study (see Table 1). Each of these sections begins with an overview of the major results demonstrated by that set of groups. These sections are divided into subsections, each dealing with one of these groups. Each of these subsections begins with an overview of the results demonstrated by that group. A comprehensive assessment of the behavior of each subject in the group during each stage of training is then provided in brief sections based on the following dependent measures:

1. Performance Measures

a. Key peck percentage figures display the percentages of trials and ITI's with a key peck for individual subjects of each species.

b. Key peck rate figures show the rates of key pecking during trials and ITI's for individual subjects of each species.

2. Behavioral Measures

a. Multiple behavior rate figures present the rates of seven behaviors shown by a representative subject of each species

during trials.

b. Brief summaries of the film analyses describe the stable behavior patterns and response topographies shown by each species during trials.

The overall average rates of key pecking and percentages of trials with a key peck shown by each species during each condition were compared using the Students t-test for independent measures (t_i) (Comrey 1975). A conservative criterion of significance ($p = .025$) was selected due to the small number of subjects per species in each group and the individual variability in some conditions. Only significant t comparisons are included in the text.

Milestone analysis tables were prepared for each group. These tables summarize the number of trials and sessions required to attain successive levels of key peck acquisition or key peck reduction during each condition. These tables also include the highest rate of key pecking and the highest percentage of trials with a key peck during a session, and the number of sessions required to reach behavioral stability. These data are presented in Tables 2-11 of the Appendix.

Experimental Conditions

There was a similar pattern of systematic behavioral changes and key peck acquisition early in autoshaping and negative automaintenance training. Later, however, different stable behavior patterns were shown by each species during each condition. Key pecking was maintained at high levels during autoshaping but not during negative automaintenance.

There were consistent species differences during these conditions in the rate and pattern of early behavioral changes, in asymptotic key pecking performance, and in the response topography of key pecking.

There were transfer effects from initial training to behavior during training on the second condition presented. During negative automaintenance following autoshaping overall key pecking performance was lower than that shown by naive subjects and none of the subjects maintained key pecking during stability. During autoshaping following negative automaintenance key pecking performance was suppressed or eliminated compared to that shown by naive subjects. There were, however, both species and individual differences in the size of these transfer effects and in the aspects of behavior and performance affected.

Group I-Autoshaping transfer to negative automaintenance. Each subject displayed systematic changes in activity and key orientation early in autoshaping. Later, each showed a gradual increase in proximity to the key, tentative head thrusts, and off-key pecking. Finally, each developed a stereotyped key pecking response topography. The rate of this behavior increased to a peak and stabilized with key pecking on most trials.

There were species differences in the rate and pattern of behavioral changes early in autoshaping and in the rate of approach to asymptotic key peck performance. There were also species differences in the asymptotic rate of key pecking, the stable behavior pattern,

and the key pecking response topography.

During negative automaintenance following autoshaping there was a gradual behavioral change and a reduction in the force and accuracy of key pecking. High rates of off-key pecking developed as key pecking decreased. During stability there were species differences in the behavior patterns displayed but none maintained either off-key or key pecking.

Autoshaping.

Performance measures. Figure 1 shows that each subject increased the percentage of trials with a key peck to a high stable level during autoshaping. Figure 2 shows that each subject also increased the rate of key pecking during trials but there were large species differences.

The blue jays increased the percentage of trials with a key peck earlier in training than the other species, but displayed the most gradual approach to asymptotic performance. They gradually increased the rate of key pecking to a peak, but then it declined and stabilized at low to intermediate levels.

The robins increased the percentage of trials with a key peck later in training, but reached asymptotic performance more quickly. They displayed erratic changes in the rate of key pecking but stabilized at intermediate to high levels.

The starlings were the last to initiate key pecking, but showed the most rapid approach to asymptotic levels of performance on both measures. The average highest rate of key pecking shown by the starlings was significantly greater than that of the robins (t_j=4.3,

Figure 1. Percentages of trials and ITIs with a key peck for individual blue jays, robins, and starlings in Group I during each session of habituation (H), magazine training (M), post-magazine training (P), Stage I-Autoshaping (FT+), and Stage II-Negative automaintenance (FT-).

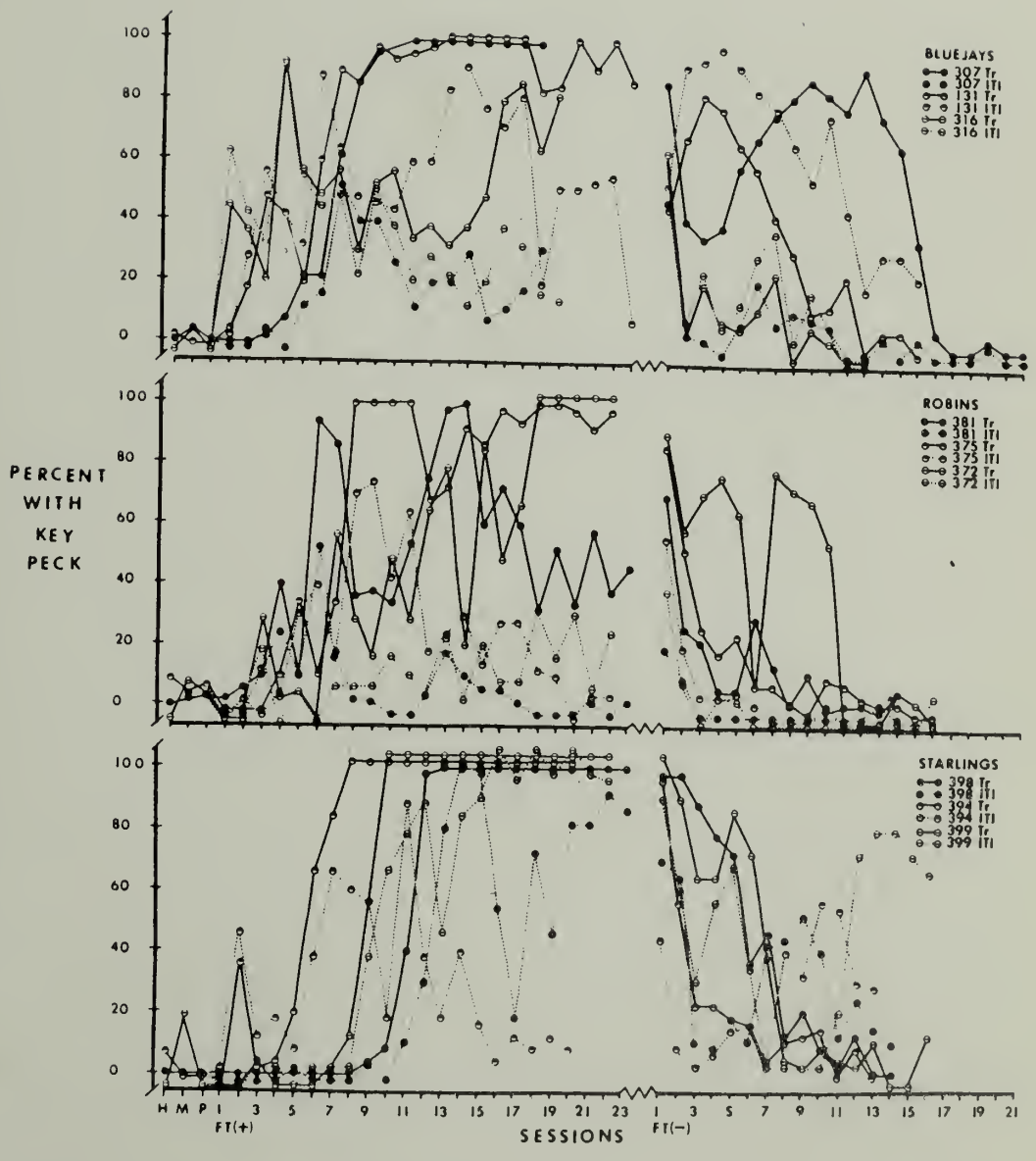
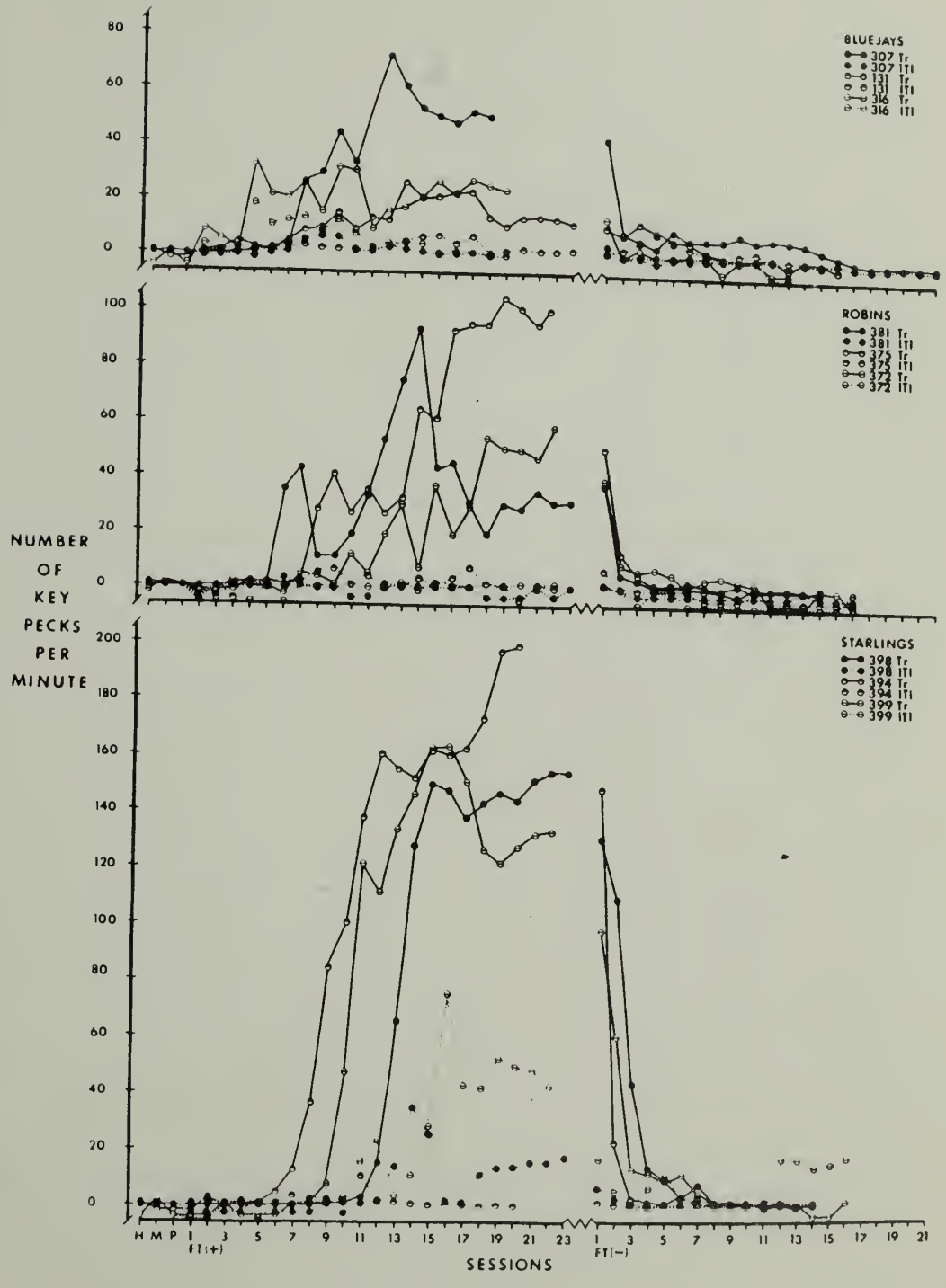

BLUEJAYS
307 Tr
307 ITI
131 Tr
131 ITI
316 Tr
316 ITI
ROBINS
381 Tr
381 ITI
375 Tr
375 ITI
372 Tr
372 ITI
STARLINGS
398 Tr
398 ITI
394 Tr
394 ITI
399 Tr
399 ITI
PERCENT WITH KEY PECK
100
80
60
40
20
0
H M P 1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21
FT(+)
FT(−)
SESSIONS

Figure 2. Rates of key pecking during trials and ITIs for individual blue jays, robins, and starlings in Group I during each session of habituation (H), magazine training (M), post-magazine training (P), Stage I-Autoshaping (FT+), and Stage II-Negative automaintenance (FT-).


BLUEJAYS
307 Tr
307 ITI
131 Tr
131 ITI
316 Tr
316 ITI
ROBINS
381 Tr
381 ITI
375 Tr
375 ITI
372 Tr
372 ITI
STARLINGS
398 Tr
398 ITI
394 Tr
394 ITI
399 Tr
399 ITI
NUMBER OF KEY PECKS PER MINUTE
SESSIONS
H M P
FT(+)
FT(−)

df=4, $p<.02$) and the blue jays ($t_j=6.3$, df=4, $p<.01$).

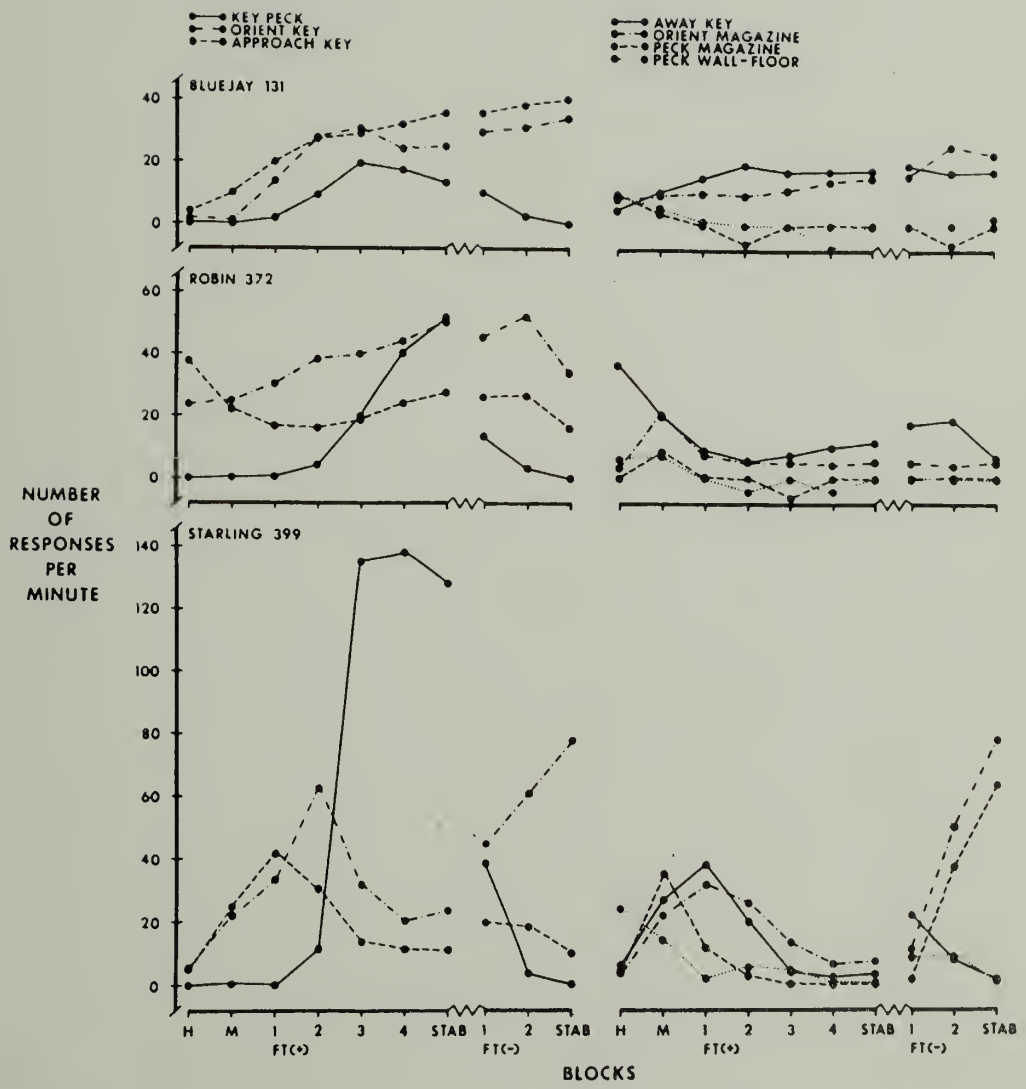
Each subject also increased the percentage of ITI's with a key peck to intermediate levels during autoshaping. The rates of ITI key pecking remained low. The blue jays and robins declined to very low levels of performance on both measures during stability. Two starlings, however, key pecked at low rates on most ITI's during stability.

Behavioral measures. Figure 3 shows that each species displayed a different pattern of behavioral changes early in autoshaping. The film analysis showed that there were also species differences during stability in the response topography of key pecking and the behavior pattern.

The blue jay increased the rates of the approach and away key responses early in training. The rates of these behaviors continued to increase during training. The rate of key orientation increased next, reached a peak, but declined during stability. The rate of key pecking increased last, reached a relatively low peak, and also declined slightly during stability.

During stability the blue jays pecked the key in bouts of several pecks. Between bouts of key pecking they moved around the cubicle but maintained orientation to the key and food magazine. They alternated erratically between two different key pecking response topographies. They pecked upward at the center of the key with a closed beak or thrust the head with the beak widely opened and snapped it shut upon contact. There was substantial variability in the force of both types of key peck.

Figure 3. Mean rate of seven behaviors during habituation (H), magazine- and post-magazine training (M), the first four five session blocks of Stage I-Autoshaping (FT+), the five session block of behavioral stability (Stab), the first two five session blocks of Stage II-Negative automaintenance (FT-), and the five session block of behavioral stability (Stab) for a representative blue jay, robin, and starling in Group I.


KEY PECK
ORIENT KEY
APPROACH KEY
AWAY KEY
ORIENT MAGAZINE
PECK MAGAZINE
PECK WALL-FLOOR
BLUEJAY 131
ROBIN 372
STARLING 399
NUMBER OF RESPONSES PER MINUTE
H M 1 2 3 4 STAB 1 2 STAB
FT(+)
FT(-)
BLOCKS

The robin did not change the rates of the approach and away key responses during training. The rate of key orientation, however, gradually increased to a peak during stability. The rate of key pecking increased later and reached an intermediate peak during stability.

During stability the robins pecked the key repeatedly but occasionally paused to orient to the reinforcement magazine. Key pecks were initiated by a rapid lunge and/or wing flap from 2-3 inches away with one or both feet leaving the floor. The head was thrust forward with the beak widely opened. Upon contact the head snapped downward, closing the beak and returning the bird to its initial position.

The starling showed large increases in the rates of the approach and away key responses early in training. The rates of these behaviors declined to initial levels during stability. The rate of key orientation showed a similar change later in training. The rate of key pecking increased much later, but it rapidly reached a very high peak and also declined somewhat during stability.

During stability the starlings remained close to the key and pecked constantly with a rhythmic motion of the mid- and upper-body leaning toward and away from the key. They contacted the key with a closed beak, opened it widely, paused briefly, leaned back, and closed the beak. There was some variability in the degree of beak opening and the force of pecking. Many pecks failed to trigger the microswitch.

Transfer to negative automaintenance.

Performance measures. Following transfer to negative automaintenance, each subject decreased key pecking performance during trials to near zero on both measures. Subjects of each species showed either a rapid decrease during the first few sessions or a gradual, erratic decrease over several sessions.

The average highest rate of key pecking shown by the starlings was again significantly greater than that of the robins (t_j=5.42, df=4, $p<.01$) and the blue jays (t_j=5.73, df=4, $p<.01$).

The blue jays and starlings increased the percentage of ITI's with a key peck to intermediate levels as the percentage of trials with a key peck decreased. Only the starlings and one blue jay, however, maintained this behavior during stability. All subjects showed very low rates of ITI key pecking except one starling which maintained an intermediate rate during stability.

Behavioral measures. Following transfer to negative automaintenance each species showed a different pattern of behavioral changes. All subjects, however, showed a decrease in the accuracy and force of key pecking and developed high rates of off-key pecking. Each species adopted a different stable pattern of behavior, but none maintained either key pecking or off-key pecking.

The blue jay gradually decreased the rate of key pecking to zero. The rates of key and magazine orientation and the approach and away key responses steadily increased reaching peak levels during stability.

During stability the blue jays showed a great deal of

activity, hopping and running rapidly around the cubicle. They frequently displayed rapid alternations in orientation between the key and reinforcement magazine. Occasionally they pecked, gripped, and tore at the reinforcement magazine, using the two types of peck topography previously described.

The robin immediately reduced the rate of key pecking to zero. The rates of key orientation and the approach and away key responses decreased gradually to low levels during stability.

During stability the robins slowly moved around the rear of the cubicle alternating hops and low crouches. Occasionally, they oriented to the key and reinforcement magazine.

The starling also immediately decreased the rate of key pecking to zero. The rates of key and magazine orientation and magazine pecking steadily increased, however, and stabilized at high levels. The rates of the approach and away key responses and wall-floor pecking showed a transitory increase but stabilized at low levels.

During stability the starlings displayed a highly stereotyped behavior pattern. They rapidly alternated between standing upright to orient to the key and crouching to peck and probe the reinforcement magazine, utilizing the previously described pecking response topography.

Group II-Negative automaintenance transfer To autoshaping. Each subject displayed systematic behavioral changes and developed a stereotyped key pecking response topography during negative automain-

tenance. Later, each showed a gradual reduction in the force and accuracy of key pecking and high rates of off-key pecking developed. Finally, the rates of both key pecking and off-key pecking stabilized at low levels.

There were species differences in the rate and pattern of behavioral changes early in negative automaintenance. There were also species differences in the rate of approach to asymptotic key peck performance, the response topography of key pecking and the highest level of key peck performance. During stability there were species differences in the behavior pattern and in the level of key peck performance.

During autoshaping following negative automaintenance there were behavioral changes and an increase in the rate of key pecking. There were, however, both species and individual differences in the pattern of behavioral changes, in the size and permanence of the increase in key peck performance, and in the stable behavior pattern.

Negative automaintenance.

Performance measures. Figures 4 and 5 show that each subject increased the percentage of trials with a key peck and the rate of key pecking during negative automaintenance. Overall key pecking performance remained low, but it changed erratically across sessions. There were large individual and species differences in key pecking performance during stability.

The blue jays showed the lowest overall level of key pecking performance and rapidly stabilized at zero on both measures.

The robins gradually increased the percentage of trials with a

Figure 4. Percentages of trials and ITIs with a key peck for individual blue jays, robins, and starlings in Group II during each session of habituation (H), magazine training (M), post-magazine training (P), Stage I-Negative automaintenance (FT-), and Stage II-Autoshaping (FT+).

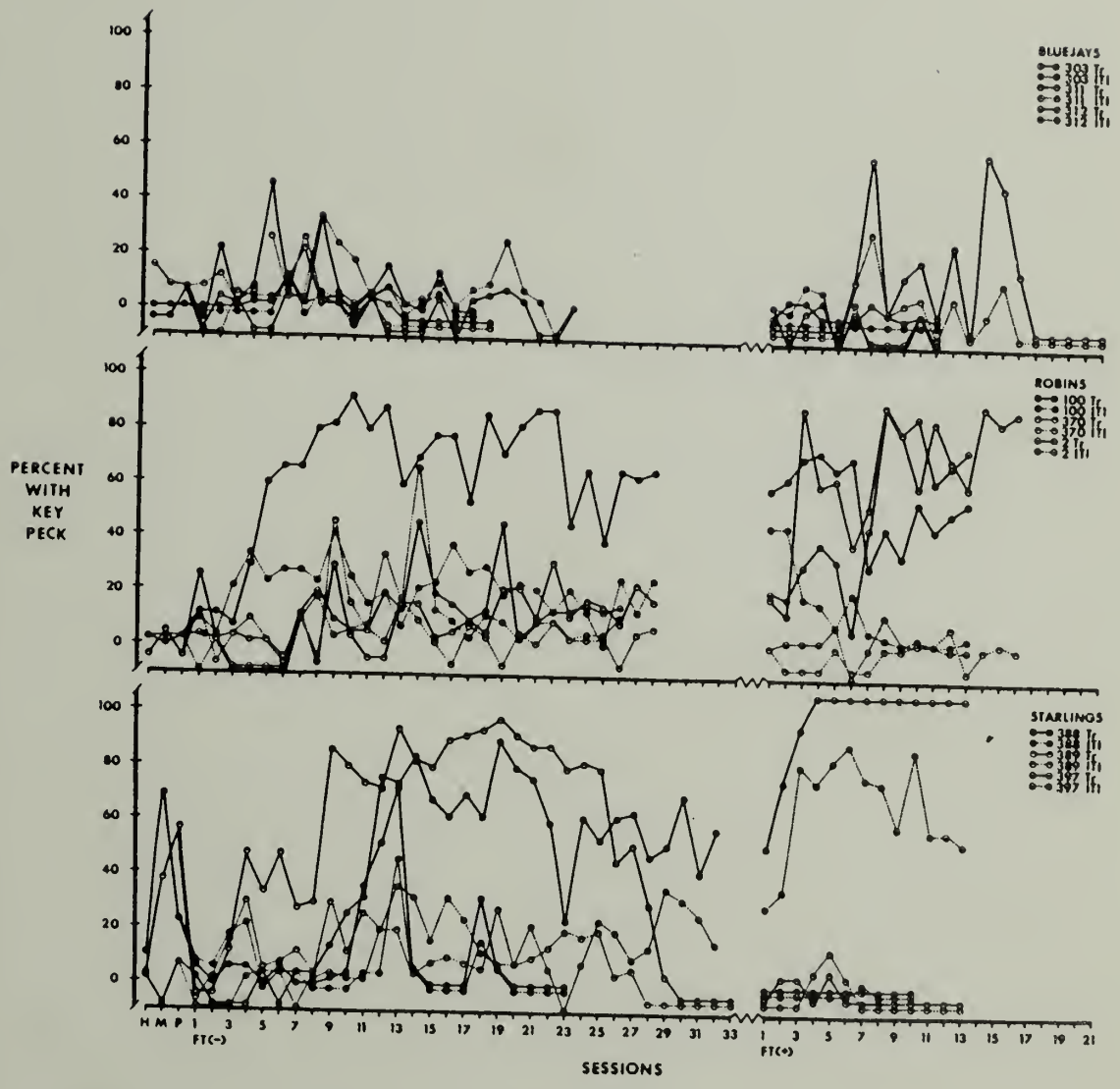
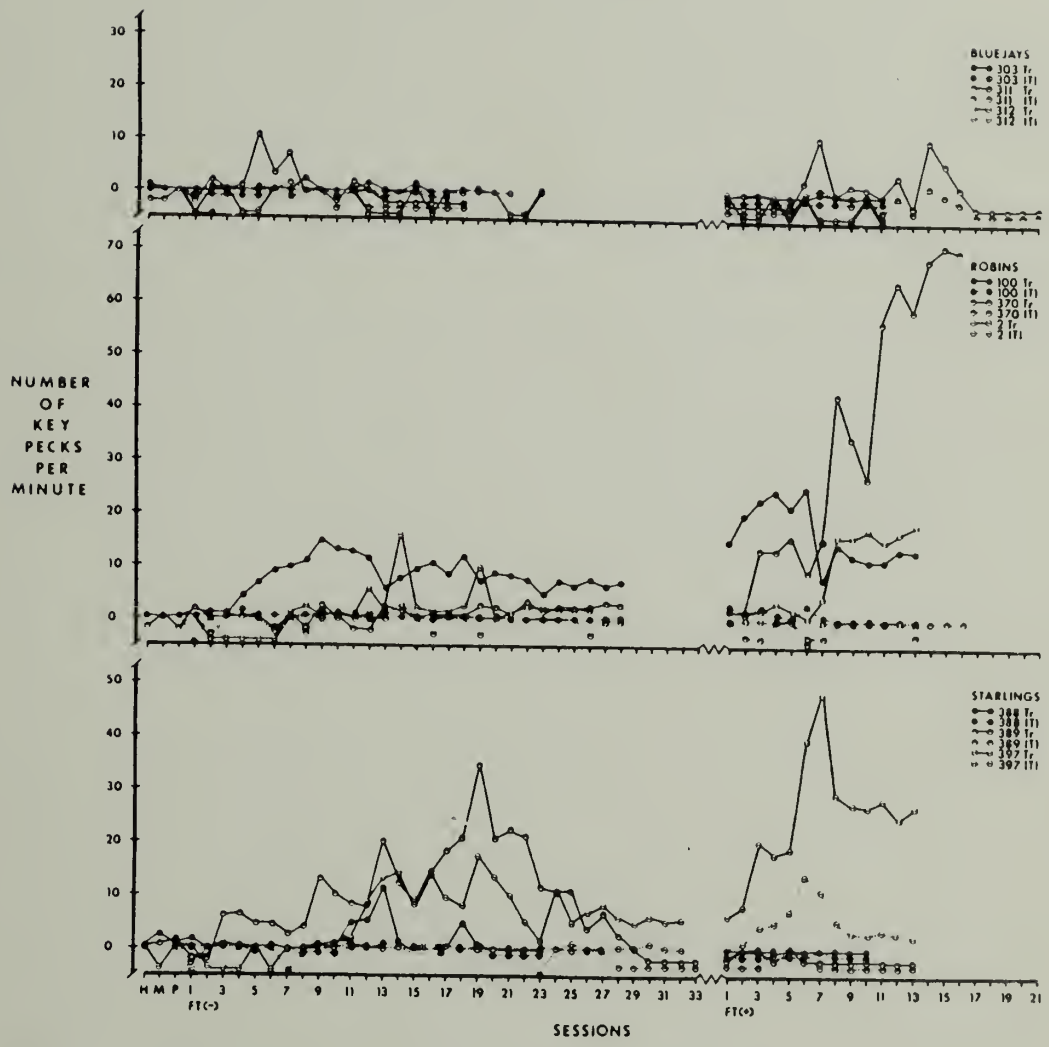

BLUEJAYS
ROBINS
STARLINGS
PERCENT WITH KEY PECK
SESSIONS
FT(−)
FT(+)

Figure 5. Rates of key pecking during trials and ITIs for individual blue jays, robins, and starlings in Group II during each session of habituation (H), magazine training (M), post-magazine training (P), Stage I-Negative automaintenance (FT-), and Stage II-Autoshaping (FT+).


BLUE JAYS
303 Tr
303 (T)
311 Tr
311 (T)
312 Tr
312 (T)
ROBINS
100 Tr
100 (T)
370 Tr
370 (T)
2 Tr
2 (T)
STARLINGS
388 Tr
388 (T)
389 Tr
389 (T)
397 Tr
397 (T)
NUMBER OF KEY PECKS PER MINUTE
H M P
FT(-)
FT(+)
SESSIONS

key peck to intermediate or high levels but then it decreased and stabilized at low to intermediate levels. They displayed low to intermediate rates of key pecking throughout training.

The starlings showed the highest overall levels of key pecking performance on both measures and maintained key pecking for many sessions. They key pecked on an intermediate to high percentage of trials at low to intermediate rates. Two of the subjects gradually stopped key pecking, but one maintained key pecking during stability. This subject key pecked on an intermediate percentage of trials at a low rate. The average highest percentage of trials with a key peck shown by the starlings was significantly greater than that shown by the blue jays ($t_j = 4.7$, $df = 4$, $p < .01$).

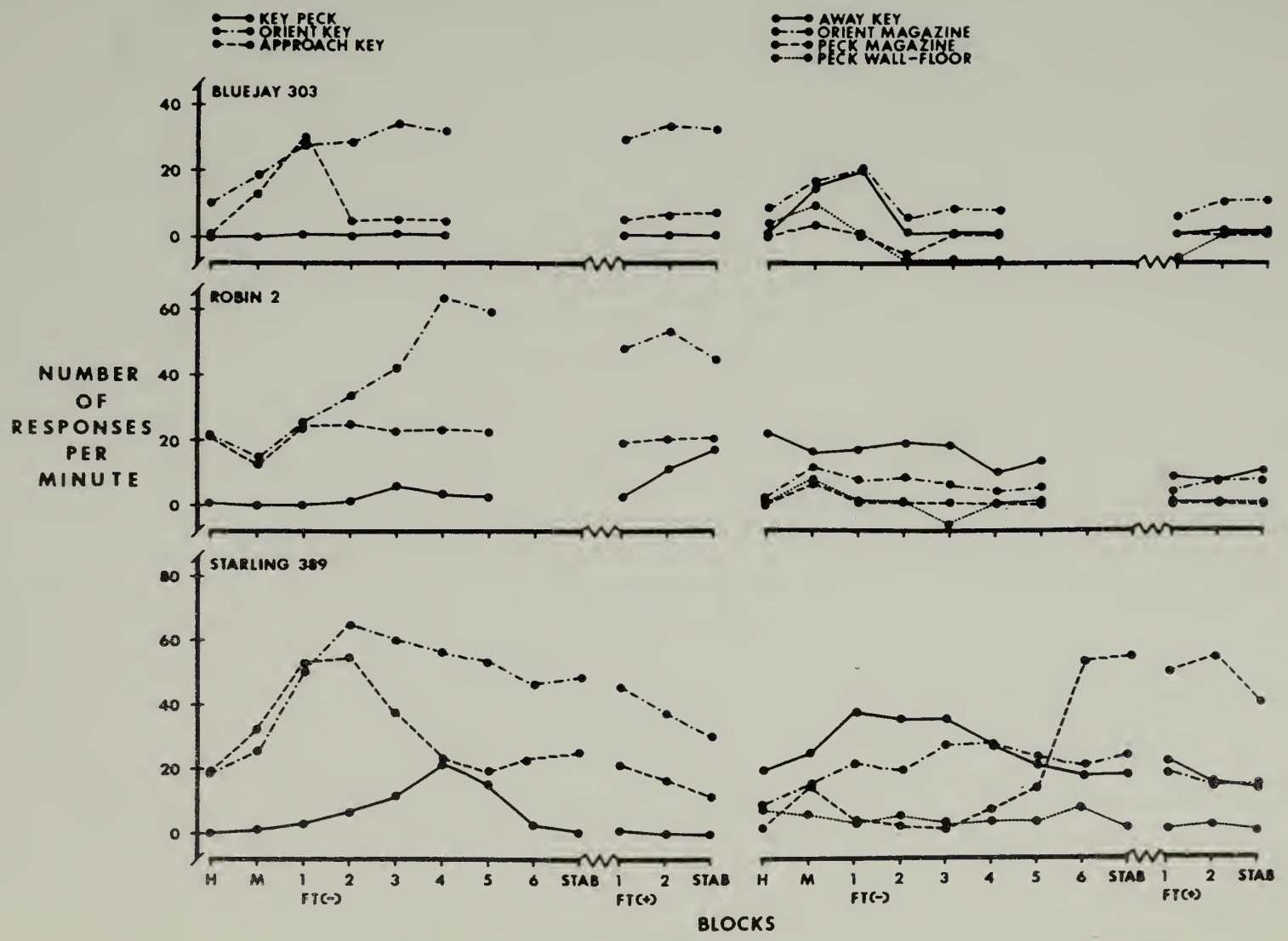
Generally, the percentage of ITI's with a key peck increased and varied with the key pecking performance during trials. There were, however, species differences in the relationship between these measures.

The starlings key pecked on a lower percentage of ITI's than trials. The blue jays showed similar performance on both measures. The robins key pecked on a higher percentage of ITI's than trials, except during stability when key pecking during ITI's decreased to near zero.

The rate of ITI key pecking shown by all subjects, however, remained near zero throughout training.

Behavioral measures. Figure 6 shows that each species displayed a different pattern of behavioral changes early in negative automaintenance. The film analysis showed that there were also spe-

Figure 6. Mean rate of seven behaviors during habituation (H), magazine- and post-magazine training (M), the first six five session blocks of Stage I-Negative automaintenance (FT-), the five session block of behavioral stability (Stab), the first six five session blocks of Stage II-Autoshaping (FT+), and the five session block of behavioral stability (Stab) for a representative blue jay, robin, and starling from Group II.


KEY PECK
ORIENT KEY
APPROACH KEY
AWAY KEY
ORIENT MAGAZINE
PECK MAGAZINE
PECK WALL-FLOOR
BLUEJAY 303
ROBIN 2
STARLING 389
NUMBER OF RESPONSES PER MINUTE
H M 1 2 3 4 5 6 STAB 1 2 STAB
FT(-)
FT(+)
BLOCKS

cies differences in the response topography of key pecking. All subjects showed a decrease in the force and accuracy of key pecking and an increase in off-key pecking was observed. There were also species differences in the behavior patterns and key pecking performance during stability.

The blue jay increased the rates of key and magazine orientation and the approach and away key responses early in training. The rates of these responses decreased abruptly, however, to low levels except for key orientation which continued to increase. The rates of all pecking responses remained near zero throughout training.

During stability the blue jays moved slowly around the cubicle but maintained almost constant orientation to the key.

The robin did not change the rates of the approach and away key responses during training. The rate of key orientation, however, increased steadily to a peak during stability. The rate of key pecking remained at zero early in training, but later increased to low levels during stability.

During stability the robins moved rapidly around the chamber. They maintained low levels of both key pecking and off-key pecking, employing the previously described response topography.

The starling steadily increased the rates of key orientation and the approach and away key responses to high levels early in training. The rate of key orientation decreased somewhat, but the rates of the approach and away key responses decreased to initial levels during stability. The rate of key pecking gradually increased to an intermediate level but declined to zero during stability. The

rate of magazine orientation showed a similar increase but remained stable. The rate of magazine pecking decreased to zero early in training but abruptly increased later to a high level during stability.

During stability the starlings displayed high rates of the previously described stereotyped behavior pattern. They alternated key orientations and magazine pecks utilizing the previously described pecking response topography.

Transfer to autoshaping.

Performance measures. Following transfer to autoshaping most subjects increased the percentage of trials and ITI's with a key peck. There were, however, species and individual differences in the size and permanence of this increase. Only those subjects which had maintained key pecking during stability on negative automaintenance displayed a large, permanent increase in this measure and in the rate of key pecking during trials.

The blue jays showed small but transient increases in the percentage of trials with a key peck and the rate of key pecking. Key pecking performance decreased during training and stabilized at zero on both measures.

The robins increased or maintained the percentage of trials with a key peck at high levels. They also showed a large increase in the rate of key pecking to intermediate or high levels. Initial increases in key pecking performance during ITI's were transitory and all stabilized near zero on both measures.

One starling emitted no key pecks and another showed only a

transitory increase in key pecking performance to very low levels. The remaining starling showed a rapid increase in key pecking performance on both these measures. This subject stabilized with key pecking on all trials at an intermediate rate. This subject also showed low rates of key pecking on a high percentage of the ITIs.

Behavioral measures. Following transfer to autoshaping there were species and individual differences in the pattern of behavioral changes. Most subjects showed some behavioral changes and increased the rate of key pecking. During training, however, some species and individuals gradually returned to the initial behavior patterns and stopped key pecking during stability. Those subjects which had maintained key pecking during negative automaintenance displayed a different behavior pattern and maintained key pecking during stability.

The blue jay slightly increased the rates of some responses but most remained stable.

During stability the blue jays displayed idiosyncratic, stereotyped activity patterns and occasional key or off-key pecks. When near the key they displayed rapid alternations of orientation between the key and reinforcement magazine and head thrusts which stopped several inches from the key.

The robin decreased the rate of key orientation slightly. The rates of the approach and away key responses remained stable but there was a large increase in the rate of key pecking to intermediate levels during stability.

During stability the robins showed frequent key pecks,

employed the previously described response topography. The force and accuracy of key pecking shown by this group declined substantially, however, compared to that shown during negative automaintenance.

The starling gradually decreased the rates of all responses.

The behavior pattern displayed by the starlings during negative automaintenance persisted during autoshaping.

Control Conditions

There were systematic behavioral changes during each of the control conditions, but relatively little key pecking. The pattern of behavioral changes and the stable behavior pattern was different in each condition.

There were species differences in the rate and pattern of behavioral changes and the response topography of key pecking during each condition. There were species differences in the level of key pecking performance during one of the conditions.

There were transfer effects from initial training to behavior during autoshaping. There were, however, both species and individual differences in the size of these transfer effects and in the aspects of behavior and performance affected.

During autoshaping following trial stimulus alone training key peck acquisition and asymptotic performance was either facilitated, unaffected, or eliminated compared to that shown by naive subjects.

During autoshaping following reinforcement alone training the normal pattern of behavioral changes, the level of asymptotic key pecking performance, or the stable behavior pattern was disrupted com-

pared to that shown by naive subjects.

During autoshaping following random trial stimulus-reinforcement training the normal pattern of key peck acquisition or the asymptotic level of key peck performance was disrupted compared to that shown by naive subjects.

Group III-Trial stimulus alone training transfer to autoshaping. Each subject displayed systematic behavioral changes and some key pecking during trial stimulus alone training. None, however, displayed high levels of key pecking.

There were species differences in the rate and pattern of behavioral changes and in the response topography of key pecking. There were also species differences in the overall level of key pecking performance. There were large individual differences within each species in the behavior pattern displayed during this training.

During autoshaping following trial stimulus alone training there were behavioral changes and some species increased the rate of key pecking. There were, however, species differences in the pattern of behavioral changes and the stable behavior pattern. There were also species differences in the level of key peck acquisition and asymptotic key pecking performance.

Trial stimulus alone training.

Performance measures. Figures 7 and 8 show that most subjects occasionally key pecked during trial stimulus alone training. There were, however, species differences in the overall level of key pecking performance.

Figure 7. Percentages of trials and ITIs with a key peck for individual blue jays, robins, and starlings in Group III during each session of habituation (H), magazine training (M), post-magazine training (P), Stage I-Trial stimulus alone training (TS), and Stage II-Autoshaping (FT+).

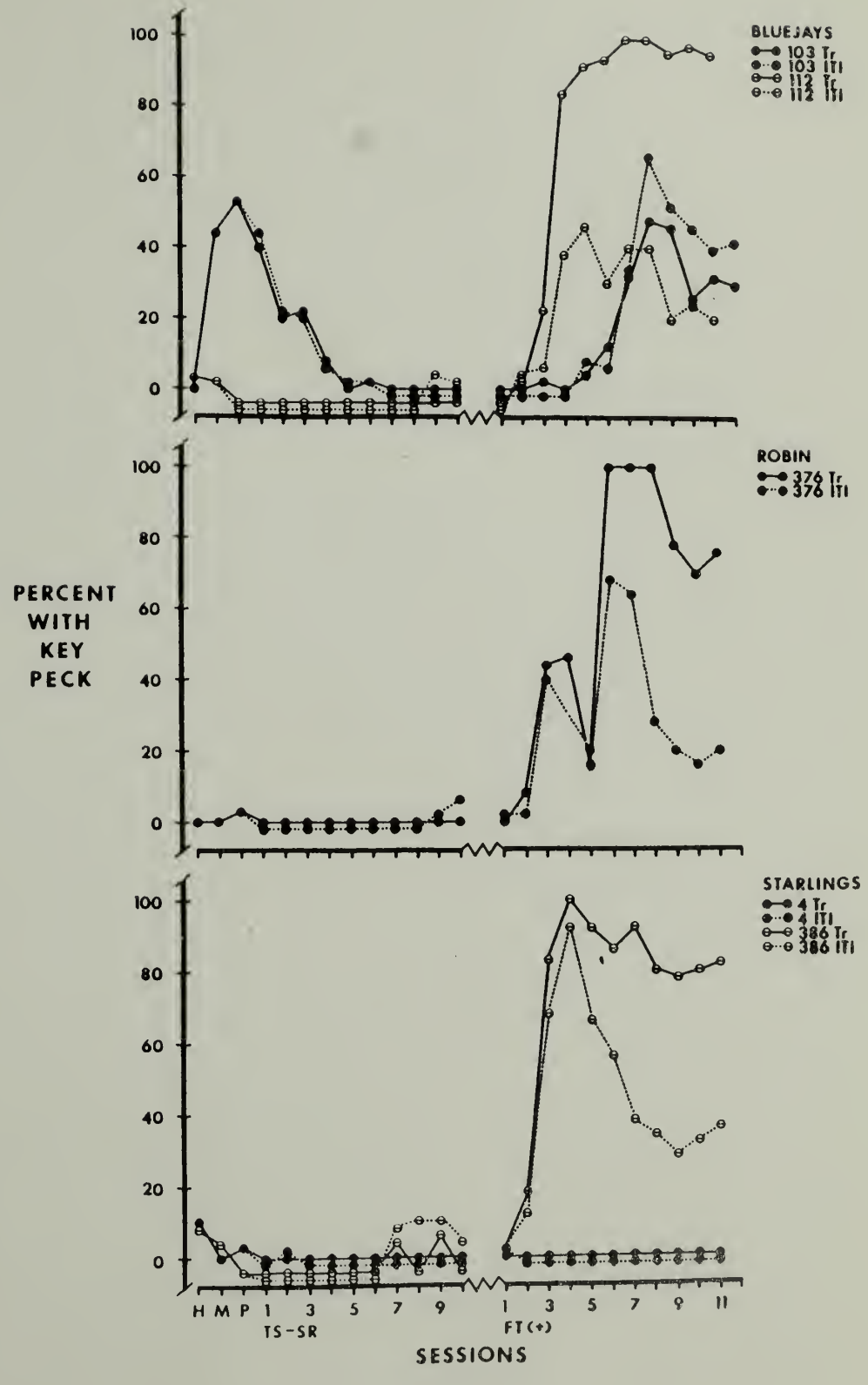
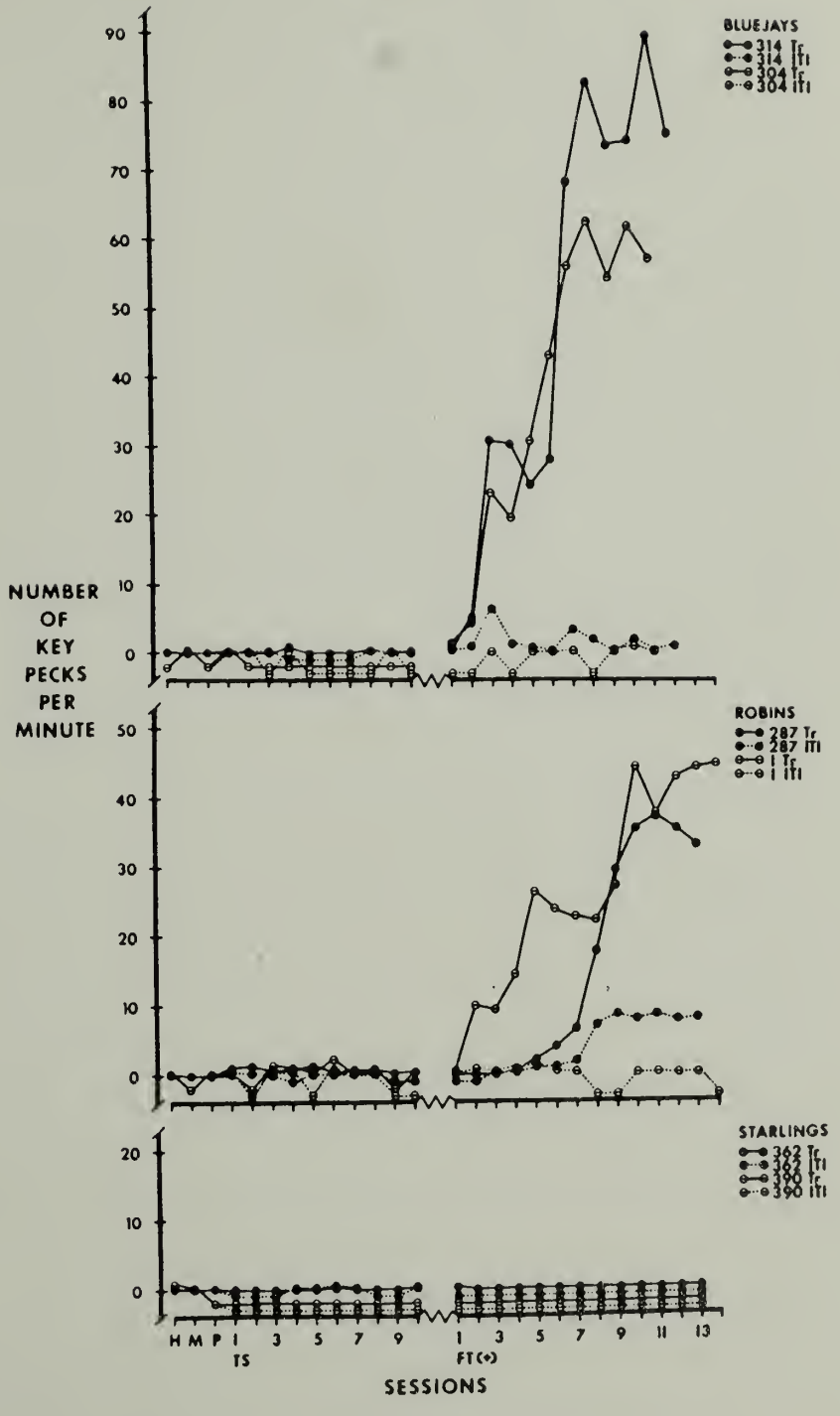

BLUEJAYS
103 Tr
103 ITI
112 Tr
112 ITI
ROBIN
376 Tr
376 ITI
STARLINGS
4 Tr
4 ITI
386 Tr
386 ITI
PERCENT WITH KEY PECK
100
80
60
40
20
0
H M P 1 3 5 7 9
TS-SR
1 3 5 7 9 11
FT(+)
SESSIONS

Figure 8. Rates of key pecking during trials and ITIs for individual blue jays, robins, and starlings in Group III during each session of habituation (H), magazine training (M), post-magazine training (P), Stage I-Trial stimulus alone training (TS), and Stage II-Autoshaping (FT+).


BLUEJAYS
314 Tr
314 ITI
304 Tr
304 ITI
ROBINS
287 Tr
287 ITI
1 Tr
1 ITI
STARLINGS
362 Tr
362 ITI
390 Tr
390 ITI
NUMBER OF KEY PECKS PER MINUTE
SESSIONS
H M P 1 3 5 7 9 1 3 5 7 9 11 13
TS
FT(+)

The blue jays and starlings key pecked during a few sessions on a very low percentage of trials and ITI's at near zero rates. They showed no key pecking during most sessions, however.

The robins increased both the percentage of trials and ITI's with a key peck and the rate of key pecking during trials. Asymptotic levels of key pecking performance on both measures were low, but they key pecked during most sessions.

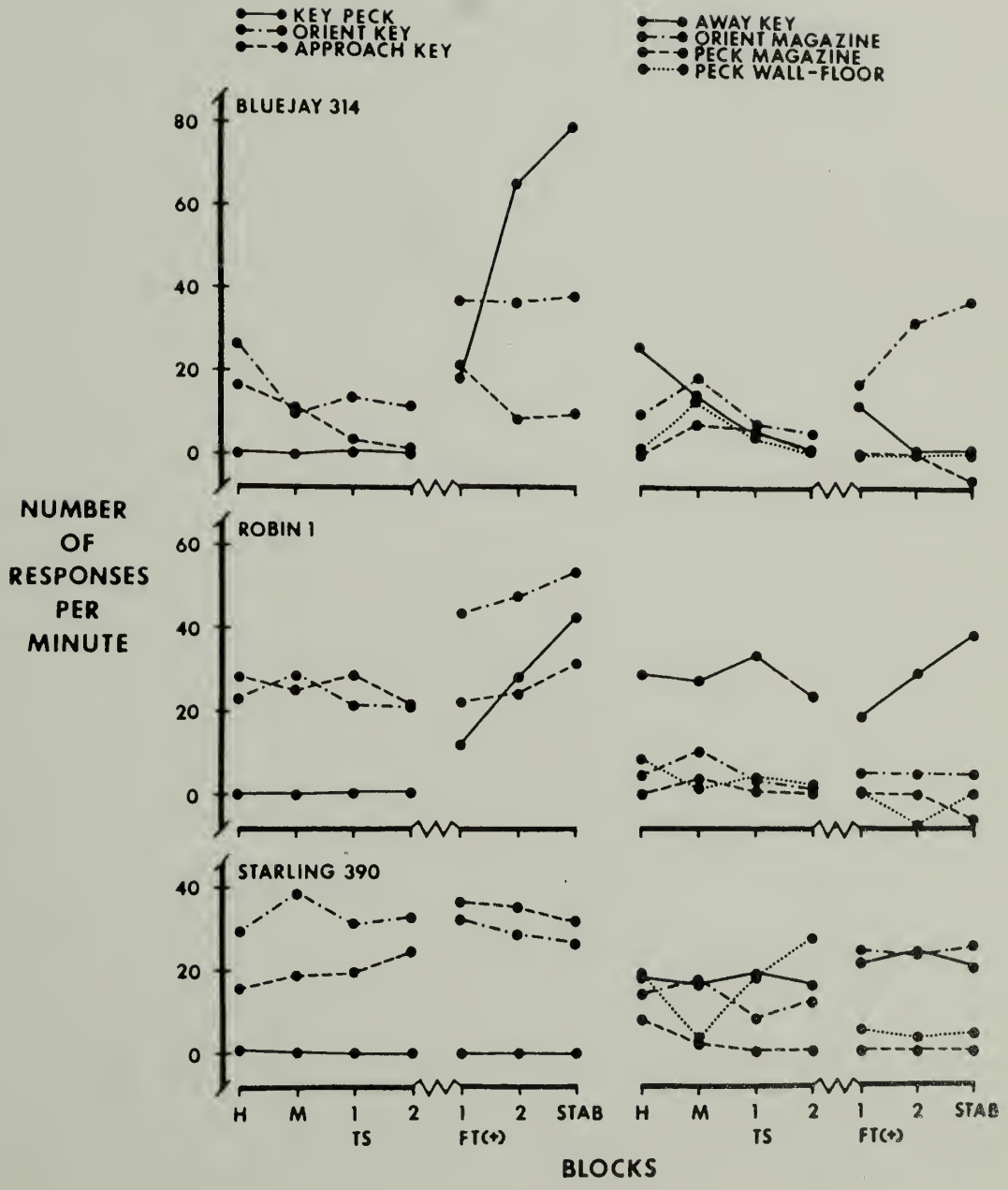
Behavioral measures. Figure 9 shows that each species displayed a different rate and pattern of behavioral changes during trial stimulus alone training. The film analysis showed that there were also species differences in the response topography of key pecking. There were also large individual differences within each species in the behavior patterns displayed during this condition.

The blue jay did not change the rate of key orientation. The rates of the rest of the behaviors scored remained at or decreased to near zero.

During training one blue jay was inactive and remained near the center of the cubicle alternating its orientation randomly. The other blue jay, however, engaged in a stereotyped activity pattern and moved around the cubicle. This subject frequently alternated its orientation between the key and reinforcement magazine. Occasionally it pecked the reinforcement magazine, utilizing the previously described response topographies.

This training had little effect on the behavior of the robin. The initial intermediate rates of key orientation and the approach and away key responses did not change. The initial low rates of the rest

Figure 9. Mean rates of seven behaviors during habituation (H), magazine- and post-magazine training (M), the two five session blocks of Stage I-Trial stimulus alone training (TS), the first two five session blocks of Stage II-Autoshaping (FT+), and the five session block of behavioral stability (Stab) for a representative blue jay, robin, and starling from Group III.


KEY PECK
ORIENT KEY
APPROACH KEY
AWAY KEY
ORIENT MAGAZINE
PECK MAGAZINE
PECK WALL-FLOOR
BLUEJAY 314
ROBIN 1
STARLING 390
NUMBER OF RESPONSES PER MINUTE
80
60
40
20
0
H M 1 2 1 2 STAB
TS
FT(+)
BLOCKS

of the behaviors scored, including key pecking, also did not change.

During training, the robins also engaged in stereotyped activity patterns and moved around the cubicle. The subjects differed, however, with one showing high rates and the other low rates of this activity. Both subjects occasionally pecked the key several times following an approach, employing the previously described response topography.

The starling decreased the rate of key orientation to an intermediate level early in training. The rates of wall-floor pecking and the approach and away key responses gradually increased to intermediate levels. The rate of magazine orientation gradually decreased to low levels and the rate of magazine pecking decreased to zero.

During training, the starlings also engaged in stereotyped activity patterns and moved around the cubicle. One subject showed high rates and the other showed low rates of this activity pattern. Both subjects constantly alternated orientation around the cubicle. Occasionally they pecked the floor and the reinforcement magazine using the previously described response topography.

Transfer to autoshaping.

Performance measures. Following transfer to autoshaping each of the subjects of two species increased key pecking performance during trials and ITI's. The subjects of the other species, however, failed to increase key pecking performance.

The blue jays and robins showed an immediate and rapid increase in the percentage of trials and ITI's with a key peck.

The blue jays increased very rapidly the rate of key pecking

during trials to high levels and stabilized.

The robins gradually increased the rate of key pecking during trials to intermediate levels and quickly stabilized.

Most of these subjects keypecked on a low to intermediate percentage of the ITI's at a very low rate. One robin, however, showed low rates of ITI key pecking during stability.

The starlings failed to increase key pecking performance during trials and ITI's on either measure.

Behavioral measures. Following transfer to autoshaping there were behavioral changes and some species increased the rate of key pecking. There were, however, species differences in the rate and pattern of behavioral changes and the stable behavior pattern. There were also species differences in the level of key peck acquisition and asymptotic key pecking performance.

The blue jay increased the rates of key and magazine orientation, the approach and away key responses, and key pecking to intermediate levels early in training. The rates of key orientation remained stable but the rates of the approach and away key responses decreased to low levels during stability. The rates of key pecking and magazine orientation steadily increased to high and very high levels, respectively, during stability.

During stability the blue jays showed high levels of key pecking employing both the previously described response topographies. They showed relatively low levels of activity but frequently alternated orientation between the key and reinforcement magazine.

Early in autoshaping the robin also increased the rate of key

orientation and key pecking to stable high and intermediate levels, respectively. The rates of the approach and away key and magazine orientation response also gradually increased reaching low to intermediate levels during stability.

During stability, the robins frequently pecked the key employing the previously described response topography. They also showed frequent key and magazine orientations, however, and often moved around the cubicle between bouts of key pecking.

The starling also increased the rates of the approach and away key and magazine orientation responses to intermediate levels early in training. There was also, however, an immediate large decrease in the rate of wall-floor pecking to low levels. The rates of these responses and key orientation remained stable or decreased somewhat during training. The rates of key and magazine pecking, however, remained at zero.

During stability, the starlings showed the same behavior patterns displayed during trial stimulus alone training.

Group IV-Reinforcement alone training transfer to autoshaping. Each subject displayed systematic behavioral changes during reinforcement alone training, but most failed to key peck.

There were species differences in the rate and pattern of behavioral changes and in the response topography of key pecking.

During autoshaping following reinforcement alone training there were behavioral changes and all subjects increased the rate of key pecking. There were, however, species differences in the rate and

pattern of behavioral changes and in the stable behavior pattern. There were also species differences in the asymptotic level of key pecking performance.

Reinforcement alone training.

Performance measures. Figures 10 and 11 show that some subjects emitted a few key pecks during reinforcement alone training.

One subject of each species key pecked on a very low percentage of the trials and ITI's at very low rates during the last few sessions.

Behavioral measures. Figure 12 shows that each species displayed a different pattern of behavioral changes during reinforcement alone training. The film analysis for this group was very short due to an equipment failure. The film and videotapes of this group showed that there were species differences in the response topographies of key pecking and in the behavior patterns shown during this condition.

The blue jay increased the rates of key and magazine orientation, the approach and away key responses, and magazine pecking to low levels. The rates of the rest of the behaviors scored remained near zero.

During training, the blue jays moved around the chamber and frequently approached and oriented to the key and reinforcement magazine. Occasionally one subject pecked the key or reinforcement magazine employing the previously described response topographies.

The robin increased the rates of the approach and away key responses to intermediate levels. There was also a small increase in

Figure 10. Percentages of trials and ITIs with a key peck for individual blue jays, robins, and starlings in Group IV during each session of habituation (H), magazine training (M), post-magazine training (P), Stage I-Reinforcement alone training (SR), and Stage II-Autoshaping (FT+).

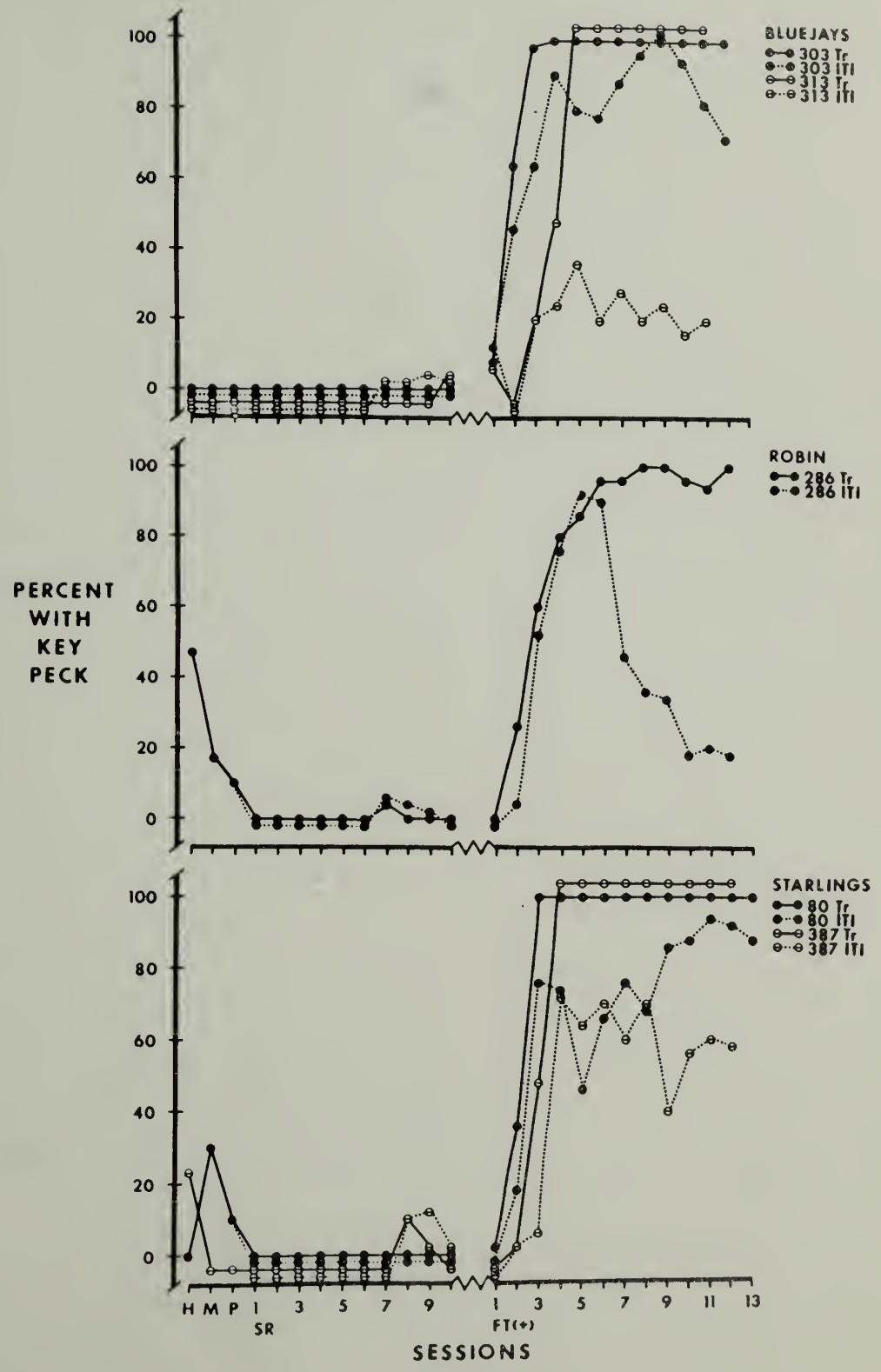

BLUEJAYS
303 Tr
303 ITI
313 Tr
313 ITI
ROBIN
286 Tr
286 ITI
STARLINGS
80 Tr
80 ITI
387 Tr
387 ITI
PERCENT WITH KEY PECK
100
80
60
40
20
0
H M P 1 3 5 7 9
SR
1 3 5 7 9 11 13
FT(+)
SESSIONS

Figure 11. Rates of key pecking during trials and ITIs for individual blue jays, robins, and starlings in Group IV during each session of habituation (H), magazine training (M), post-magazine training (P), Stage I-Reinforcement alone training (SR), and Stage II-Autoshaping (FT+).

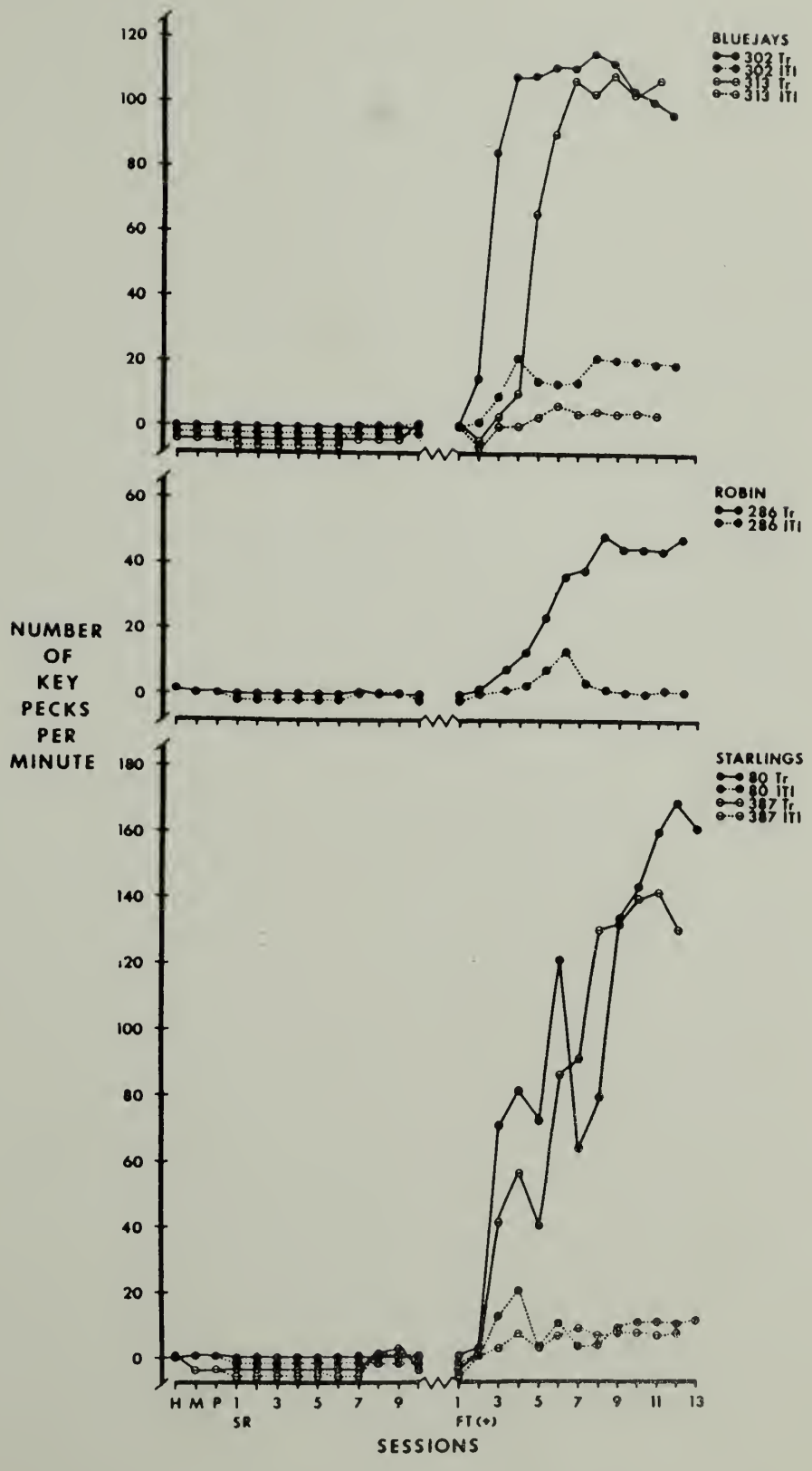
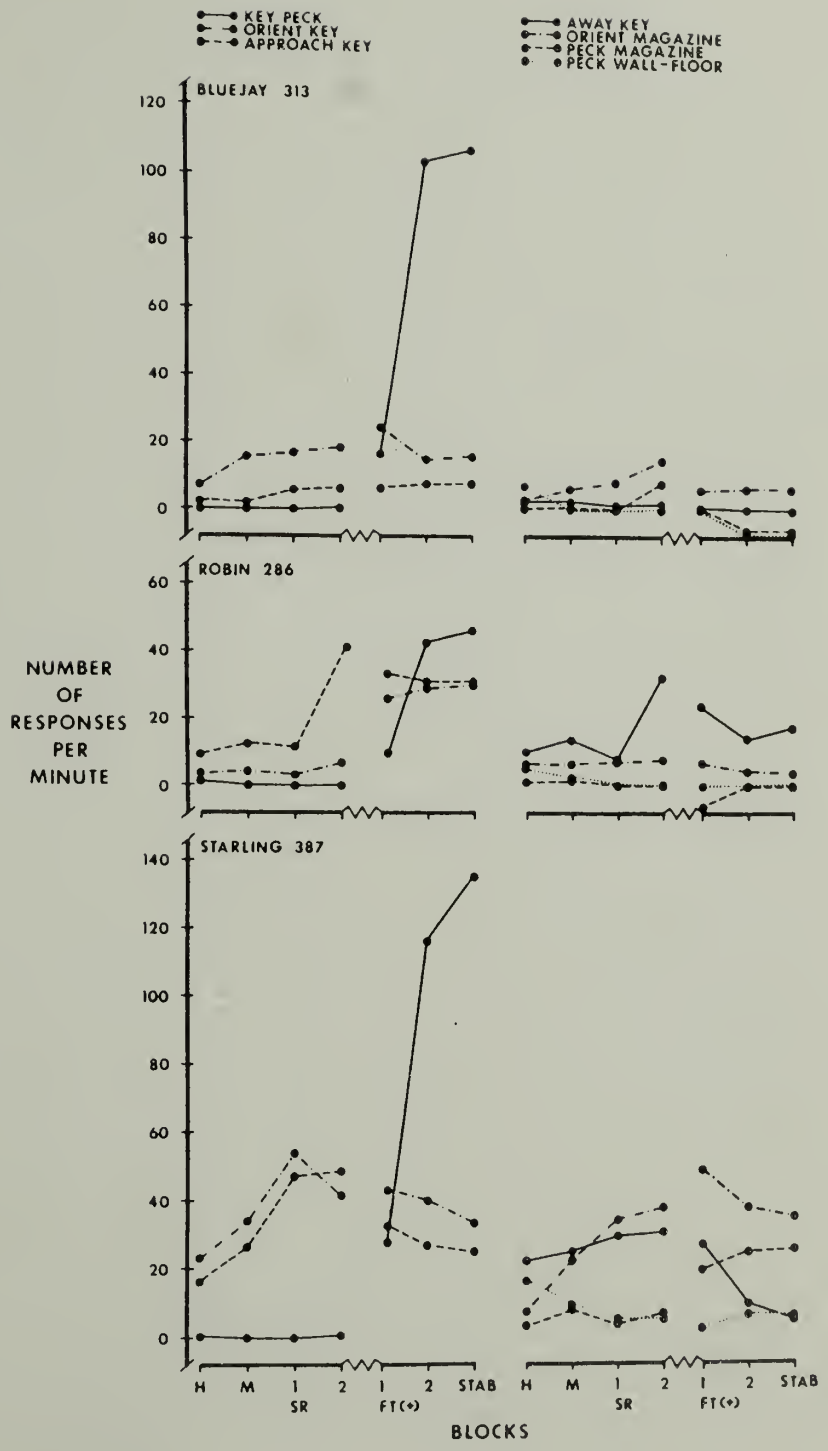

BLUEJAYS
302 Tr
302 ITI
313 Tr
313 ITI
ROBIN
286 Tr
286 ITI
STARLINGS
80 Tr
80 ITI
387 Tr
387 ITI
NUMBER OF KEY PECKS PER MINUTE
H M P 1 3 5 7 9 1 3 5 7 9 11 13
SR
FT (+)
SESSIONS

Figure 12. Mean rate of seven behaviors during habituation (H), magazine- and post-magazine training (M), the two five session blocks of Stage I-Reinforcement alone training (SR), the first two five session blocks of Stage II-Autoshaping (FT+), and the five session block of behavioral stability (Stab) for a representative blue jay, robin, and starling from Group IV.


KEY PECK
ORIENT KEY
APPROACH KEY
AWAY KEY
ORIENT MAGAZINE
PECK MAGAZINE
PECK WALL-FLOOR
BLUEJAY 313
ROBIN 286
STARLING 387
NUMBER OF RESPONSES PER MINUTE
H M 1 2 1 2 STAB H M 1 2 1 2 STAB
SR FT(+) SR FT(+)
BLOCKS

the rate of key orientation, but the rest of the behaviors scored remained stable at low rates.

During training, the robins also moved around the chamber and frequently approached and oriented to the key and reinforcement magazine. One subject also occasionally pecked the key or reinforcement magazine, employing the previously described response topography.

The starling steadily increased the rates of key and magazine orientation and the approach and away key responses to intermediate levels. Magazine and wall floor pecking occurred at low stable rates.

During training, the starlings also engaged in activity patterns and moved around the chamber. They frequently oriented to the key and approached the key area. One subject also occasionally pecked the key or reinforcement magazine following an approach, employing the previously described response topography.

Transfer to autoshaping.

Performance measures. Following transfer to autoshaping each subject increased key pecking performance during trials and ITI's.

During the first few sessions each subject abruptly increased the percentage of trials with a key peck and quickly stabilized with key pecking on most trials.

The blue jays very rapidly increased the rate of key pecking during trials to high stable levels.

The robin gradually increased the rate of key pecking during trials to a stable intermediate level.

The starlings rapidly, but erratically, increased the rate of key pecking during trials to very high stable levels.

All subjects also rapidly increased the percentage of ITI's with a key peck to high levels, except for one blue jay which only reached an intermediate level. All subjects increased the rate of ITI key pecking to low levels. These levels of ITI key pecking were maintained during stability by all the subjects, except for one robin. This subject gradually decreased performance and stabilized key pecking on a low percentage of the ITI's at a very low rate.

Behavioral measures. Following transfer to autoshaping all subjects showed behavioral changes and increased the rate of key pecking. There were, however, species differences in the rate and pattern of behavioral changes, in the asymptotic levels of key pecking, and in the stable behavior patterns.

The blue jay showed a small transient increase in the rate of key orientation. The rates of the approach and away key responses gradually increased to low levels. The rate of key pecking increased to low levels early in training but later increased rapidly and stabilized at a high level.

During stability, the blue jays pecked the key repeatedly but occasionally paused to orient toward the reinforcement magazine. They showed little activity or movement around the cubicle. They employed both of the previously described key peck response topographies.

The robin increased the rate of key orientation to a stable intermediate level. The rates of the approach and away key responses decreased, however, but stabilized at the same intermediate level.

The rate of key pecking increased to low levels early in training but later increased to intermediate levels during stability.

During stability, the robins pecked the key in bouts of several pecks, employing the previously described response topography. They paused between bouts of pecking to move around the chamber and frequently oriented to the key and reinforcement magazine.

The starling showed a small transient increase in the rate of key and magazine orientation. The rates of the approach and away-key responses gradually decreased to low levels during training. The rate of key pecking showed a rapid increase to very high rates during stability. The rates of magazine and wallfloor pecking also increased to intermediate and low levels, respectively.

During stability, the starlings remained near the key and pecked the key in long bouts, employing the previously described response topography. They occasionally paused between bouts of key pecking and rapidly alternated orientation between the key and magazine. Often during these pauses they also pecked the wall below the key and the food magazine, again employing the previously described response topography.

Group V-Random trial stimulus-reinforcement training transfer to autoshaping. Each subject displayed systematic behavioral changes during random trial stimulus-reinforcement training. Most subjects also displayed some key pecking.

There were species differences in the rate and pattern of behavioral changes and in the response topography of key pecking.

There were also large individual differences within each species in the behavior pattern.

During autoshaping following random trial stimulus-reinforcement training there were behavioral changes and most subjects increased the rate of key pecking. There were, however, both species and individual differences in the rate and pattern of behavioral changes and in the stable behavior pattern. There were also both species and individual differences in the level of key peck acquisition and the asymptotic level of key pecking performance.

Random trial stimulus-reinforcement training.

Performance measures. Figures 13 and 14 show that one subject of each species key pecked on a very low percentage of trials and ITI's at a very low rate during the last few sessions of random trial stimulus-reinforcement training. One blue jay, however, initiated key pecking during pretraining and maintained key pecking during the first few sessions of training on a low percentage of the trials and ITI's at a very low rate.

Behavioral measures. Figure 15 shows that each species displayed a different pattern of behavioral changes during random trial stimulus-reinforcmeent training. The film analysis showed that there were also species differences in the response topography of key pecking. There were both species and individual differences in the behavior patterns shown during this condition.

The blue jay decreased the rates of magazine pecking, the approach and away key responses to zero. The rate of key orientation increased to low levels but the rates of magazine orientation and

Figure 13. Percentages of trials and ITIs with a key peck for individual blue jays, robins, and starlings in Group V during each session of habituation (H), magazine training (M), post-magazine training (P), Stage I-Random trial stimulus-reinforcement training (TS-SR), and Stage II-Autoshaping (FT+).

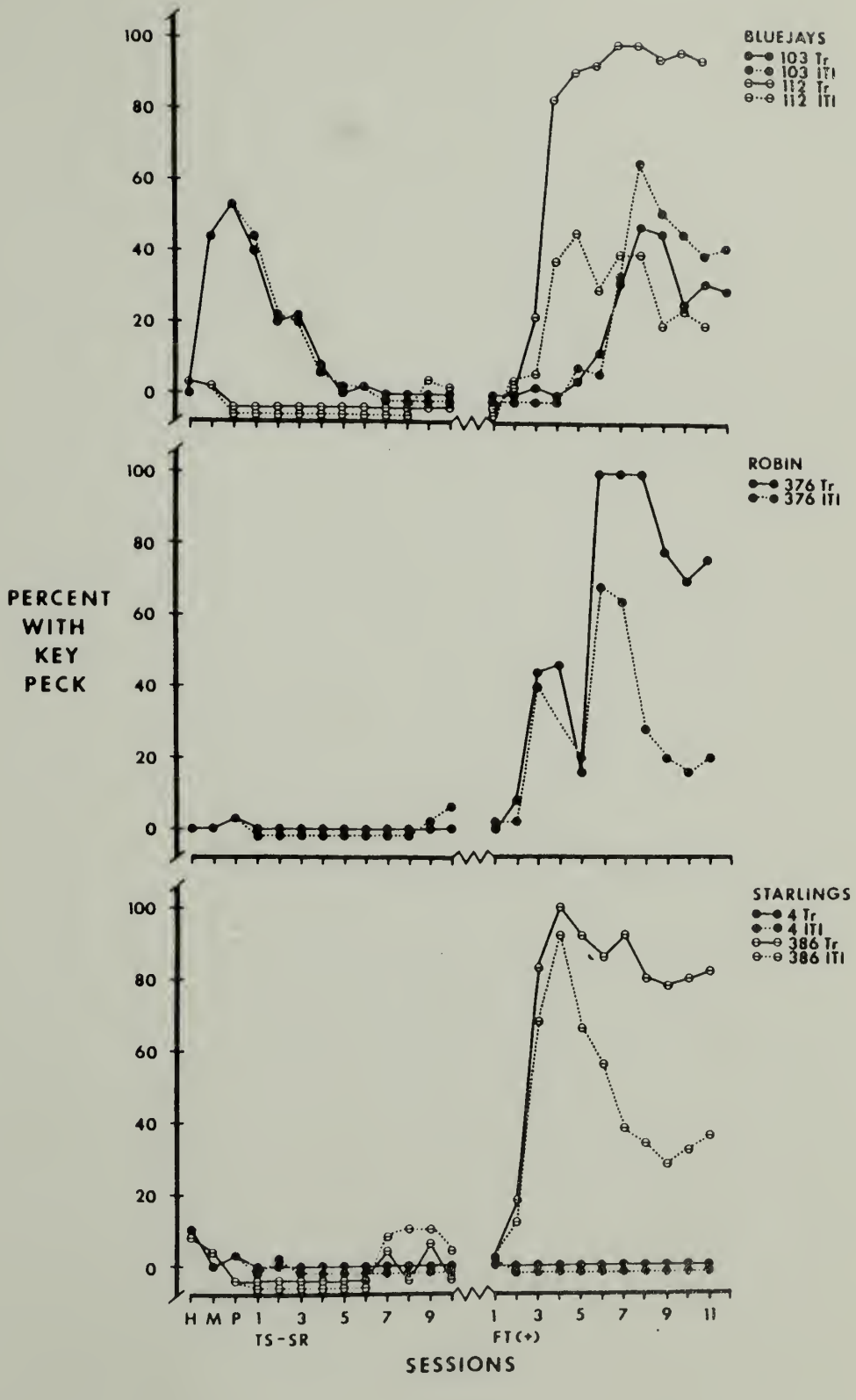

BLUEJAYS
103 Tr
103 ITI
112 Tr
112 ITI
ROBIN
376 Tr
376 ITI
STARLINGS
4 Tr
4 ITI
386 Tr
386 ITI
PERCENT WITH KEY PECK
100
80
60
40
20
0
H M P 1 3 5 7 9
TS-SR
1 3 5 7 9 11
FT(+)
SESSIONS

Figure 14. Rates of key pecking during trials and ITIs for individual blue jays, robins, and starlings in Group V during each session of habituation (H), magazine training (M), post-magazine training (P), Stage I-Random trial stimulus-reinforcement training (TS-SR), and Stage II-Autoshaping (FT+).

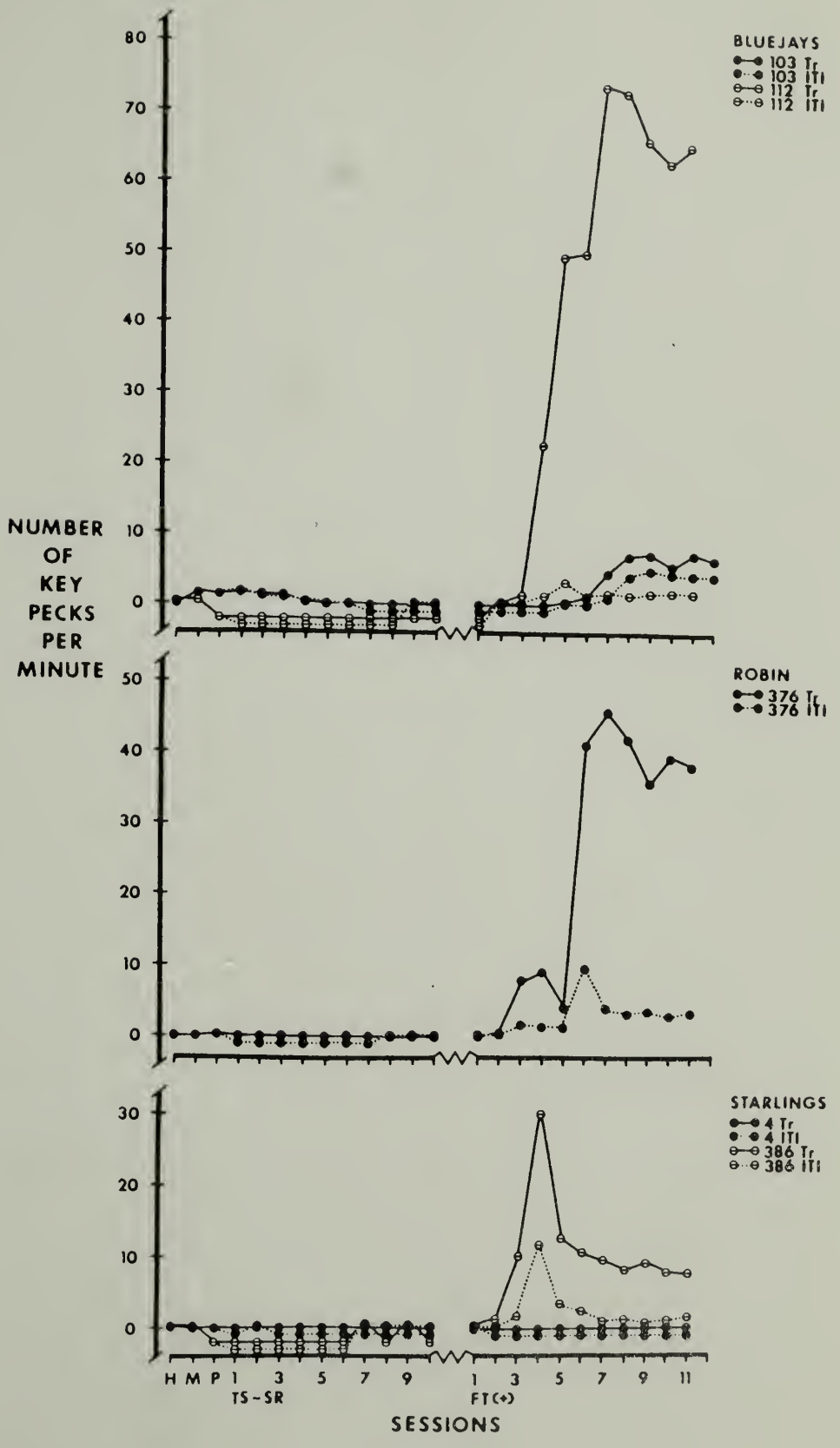
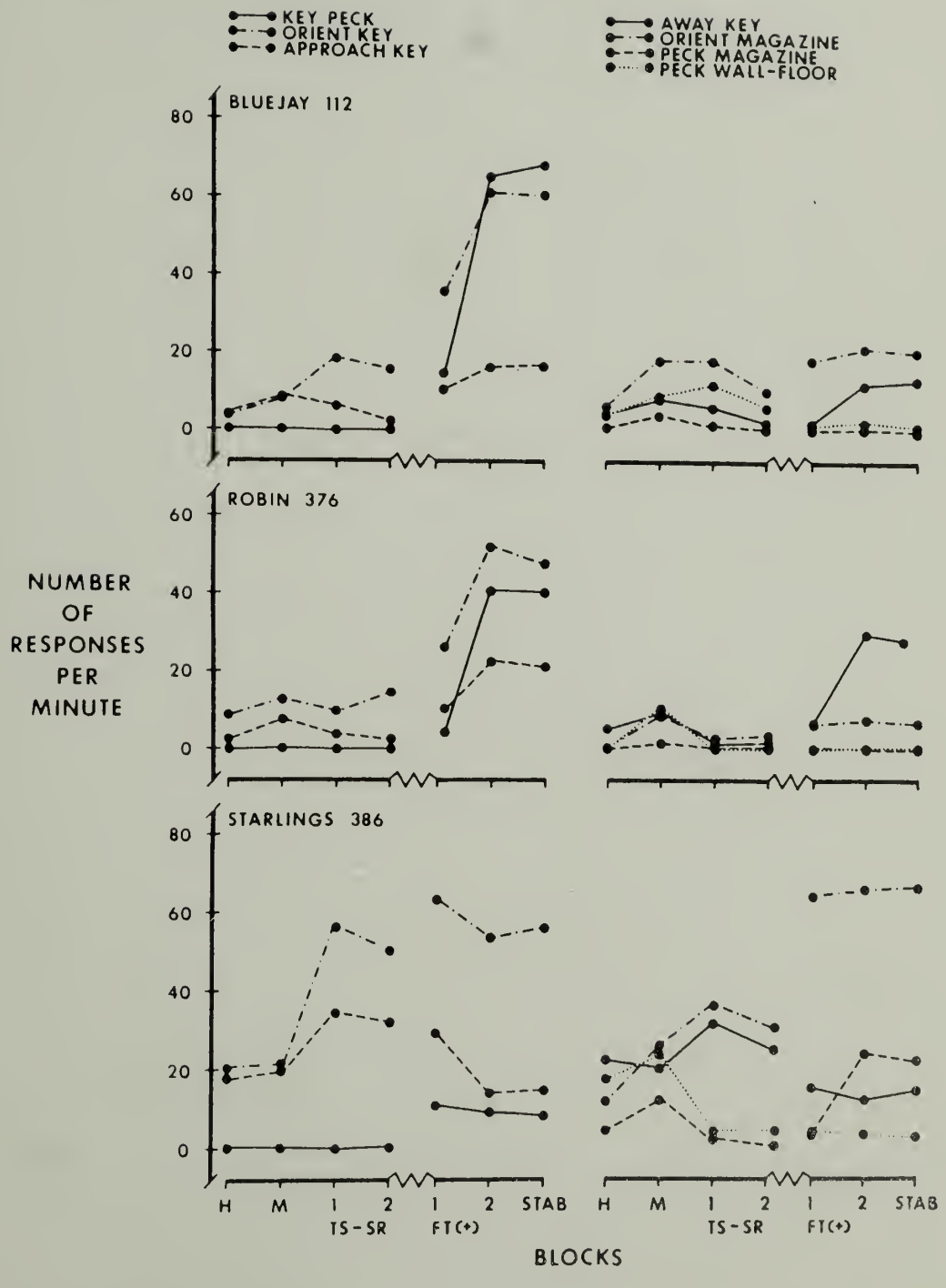

BLUEJAYS
103 Tr
103 ITI
112 Tr
112 ITI
ROBIN
376 Tr
376 ITI
STARLINGS
4 Tr
4 ITI
386 Tr
386 ITI
NUMBER OF KEY PECKS PER MINUTE
80
70
60
50
40
30
20
10
0
50
40
30
20
10
0
30
20
10
0
H M P 1 3 5 7 9 1 3 5 7 9 11
TS-SR
FT(+)
SESSIONS

Figure 15. Mean rate of seven behaviors during habituation (H), magazine- and post-magazine training (M), the two five session blocks of Stage I-Random trial stimulus-reinforcement training (TS-SR), the first two five session blocks of Stage II-Autoshaping (FT+), and the five session block of behavioral stability (Stab) for a representative blue jay, robin, and starling from Group V.


KEY PECK
ORIENT KEY
APPROACH KEY
AWAY KEY
ORIENT MAGAZINE
PECK MAGAZINE
PECK WALL-FLOOR
BLUEJAY 112
ROBIN 376
STARLINGS 386
NUMBER OF RESPONSES PER MINUTE
80
60
40
20
0
H
M
1
2
STAB
TS-SR
FT(+)
BLOCKS

wall-floor pecking decreased to low levels.

During training one blue jay was inactive but the other moved around the chamber in a stereotyped activity pattern and alternated orientation between the key and reinforcement magazine. At the end of training both were inactive and sat in the middle of the cubicle orienting randomly around the cubicle.

The robin decreased the rates of all responses except key orientation to near zero. The rate of key orientation remained stable at a low level.

During training the robin was also inactive and alternated orientation around the cubicle and between the key and reinforcement magazine in a stereotyped pattern.

The starling increased the rates of magazine orientation and the approach and away-key responses to high levels. The rates of these responses decreased somewhat later in training. The rates of all pecking behaviors decreased to or remained at zero.

During training the starlings moved around the cubicle in a stereotyped activity pattern. They frequently oriented to the key and reinforcement magazine and occasionally pecked the reinforcement magazine with the previously described response topography. At the end of training one starling was inactive and alternated orientation around the cubicle in a stereotyped pattern. The other starling showed very high rates of the previously described activity pattern.

Transfer to autoshaping.

Performance measures. Following transfer to autoshaping all except one subject increased key pecking performance during trials

and ITI's. There were, however, large species and individual differences in the rate and level of key peck acquisition and the level of asymptotic key pecking performance.

One blue jay immediately increased the percentage of trials and ITI's with a key peck and stabilized with key pecking on most trials. The percentage of ITI's with a peck gradually decreased to low levels. The rate of key pecking during trials also rapidly increased to high levels but decreased somewhat during stability. The rate of ITI key pecking also increased but remained at a low level. The other blue jay showed no change in key pecking during the first few sessions. Later, the percentage of both trials and ITI's with a key peck rapidly increased to intermediate levels but decreased to low levels during stability. The rate of key pecking during trials and ITI's gradually increased to low levels during stability.

The robin increased the percentage of trials and ITI's with a key peck and the rate of key pecking during the first few sessions. Key pecking was maintained on all trials at an intermediate rate and on most ITI's at a low rate for several sessions. Performance then decreased, however, and stabilized with key pecking on a high percentage of trials at an intermediate rate and on an intermediate percentage of the ITI's at a low rate.

One starling failed to increase key pecking performance. The other, however, rapidly increased the percentage of trials and ITI's with a key peck to high levels. The rate of key pecking also rapidly increased during trials and ITI's to intermediate and low levels, respectively. Performance gradually decreased, however, and during

stability key pecking occurred on a high percentage of trials at a low rate. Key pecking occurred on an intermediate percentage of the ITI's but at a very low rate.

Behavioral measures. Following transfer to autoshaping most subjects showed behavioral changes and increased the rate of key pecking. There were, however, both species and individual differences in the rate and pattern of behavioral changes, in the asymptotic levels of key pecking, and in the stable behavior pattern.

The blue jay rapidly increased the rates of key orientation and key pecking and stabilized at high levels. The rates of magazine orientation and the approach and away key responses also increased to intermediate levels duirng stability.

During stability the blue jays pecked the key in bouts of several pecks employing the previously described response topographies. One subject remained close to the key, showed little activity and key pecked on all trials. The other subject showed more activity and movement about the cubicle between bouts of key pecking. One some trials, however, this bird failed to key peck and displayed the pattern of behavior shown during random trial stimulus-reinforcement training.

The robin immediately increased the rate of key orientation and stabilized at a high level. The rates of key pecking and the approach and away key responses increased more gradually and stabilized at intermediate levels. The rate of magazine orientation also increased and stabilized at a low level.

During stability the robin pecked the key in bouts of a few

key pecks or off-key employing the previously described response topography. Frequently, the bird moved around the cubicle between bouts of key pecking and alternated orientation between the key and reinforcement magazine.

The starling showed a small but transient increase in the rate of key orientation but stabilized at an intermediate level. The rates of the approach and away key responses decreased to low levels during stability. The rate of key pecking immediately increased to a low level, however, and remained stable. The rate of magazine orientation increased to a high stable level. The rate of magazine pecking increased to intermediate rates during stability.

During autoshaping the starling which had shown low levels of activity during random trial stimulus-reinforcement training displayed a transient increase in activity. During stability, however, this subject displayed the same behavior pattern and low levels of activity as shown during the previous condition. The other subject was inactive early in autoshaping and alternated orientation between the key and reinforcement magazine. During stability, however, the frequency of this behavior pattern increased and the bird occasionally pecked the key or reinforcement magazine using the previously described response topography.

CHAPTER IV

DISCUSSION

Organization and Contents

This section summarizes the organization and contents of the chapter. The study yielded a large and complex set of data which may be summarized under five major results. These major results have important implications concerning:

(1) the comparative generality of autoshaping and negative automaintenance;

(2) the effects of behavioral specializations on performance during these conditions; and

(3) theoretical interpretations of these and other learning phenomena.

To clarify these implications, this chapter is divided into three sections, each containing several subsections.

The first section discusses four of the major results of the study. These major results are based on the similarities in behavior shown during:

1. Autoshaping.
2. Negative automaintenance.
3. The control conditions.
4. The transfer conditions.

This section contains a brief subsection summarizing each of these major results. Four subsections follow, providing a description and functional interpretation of the type of learning process suggested by each of these major results.

The second section discusses the fifth major result of the study. This major result is based on the differences in behavior shown by these and other species during each condition employed in the study. This section contains a brief subsection summarizing this major result. Three subsections follow, describing the functional relationship between the distinctive behavior patterns and learning processes shown by each species in the study and their species typical adaptations for feeding.

The final section summarizes the major theoretical implications of the current and past research in autoshaping and negative automaintenance. The first sub-section summarizes the implications of this research for traditional two-process learning theory. The basic assumptions and characteristics of an alternative theory are presented in the second subsection. This approach is critiqued and its adequacy to accommodate the results of this research is assessed. Several areas where this theory may be extended and refined are suggested at the end of this subsection. Directions for future research to experimentally test this approach are outlined in the last subsection.

Interspecific Behavioral Similarities

Summary of major results. The behavior of each species in the study supported the following major results:

1. The acquisition and maintenance of high levels of key pecking during autoshaping.
2. The acquisition of key pecking during negative automaintenance, but failure to maintain high levels of this behavior.
3. Systematic behavioral changes during each of the control conditions, but failure to acquire high levels of key pecking.
4. Systematic transfer effects from previous experience on behavior during autoshaping and negative automaintenance.

Behavior during autoshaping. The demonstration of autoshaping with these species supports previous research and extends the comparative generality of this phenomenon.

These species are representative of three divergent passerine families. The demonstration of autoshaping in these species suggests that this learning process may also control this type of behavior in other species of these families. At a more general level, this result suggests that the learning process represented by autoshaping may be a fundamental adaptation controlling the feeding behavior of these and other passerine families.

Behavioral changes during acquisition. Each species displayed changes in key orientation and activity early in autoshaping, prior to key peck acquisition. These behavioral changes were similar to those shown by pigeons (Brown and Jenkins 1968; Wessells 1974; Lucas 1975)

and bobwhite quail (Gardner 1969a) during autoshaping. This similarity suggests that changes in these behaviors may be characteristic of the feeding response systems of these and other avian families. This similarity also supports the notion that autoshaping is a complex process involving the control of a sequence of related behavioral components.

These behavioral changes probably represent reactions which function to increase the animals' attention and proximity to stimuli associated with new food resources. The increase in attention would facilitate detection of similar stimuli in the future. It would also improve the potential for learning about the relationship of the stimulus to consumption of the food resource. The increase in proximity to the stimulus would facilitate manipulation of the stimulus and consumption of the food resource.

Stereotyped key pecking response topographies. Each species displayed a highly stereotyped key pecking response topography during autoshaping. Similar stereotyped pecking response topographies have also been observed during autoshaping with pigeons (Jenkins and Moore 1973) and bobwhite quail (Gardner 1969a,b). This similarity suggests that stereotyped pecking response topographies are characteristic of the feeding response systems of many avian families.

Naturalistic research on each of these species provides evidence that these response topographies are exhibited in the natural environment during the consumption of food (Wolin 1948; Lorenz 1949; Dunnett 1955; Hardy 1961; Heddner 1965; Gardner 1969a,b). These response topographies facilitate the consumption of either a wide

variety of food resources or a specific food item. This difference depends on whether the species exhibits a generalized or highly specialized feeding adaptation.

The stereotyped nature of these response topographies suggests that these and other avian species have evolved particular behaviors to facilitate feeding. The occurrence of these behaviors during autoshaping supports the notion that this situation provides the necessary conditions for the control of this type of behavior. The autoshaping procedure may, in fact, simulate the process by which animals learn to recognize and respond appropriately to food items in nature.

This type of learning process would be highly functional for species with both generalized and specialized feeding adaptations. The stereotyped response topography would facilitate the capture and consumption of certain general or specific classes of food resources. These classes would be defined by the physical characteristics of the food resources such as size, color, shape, texture, etc. There would be some flexibility, however, in the particular food items selected within these classes. This flexibility would facilitate the adaptation of the species to environments with different food resources and to seasonal fluctuations in the availability of particular food items.

Behavior during negative automaintenance. The demonstration of key peck acquisition during negative automaintenance with these species also supports previous research and extends the comparative generality of this phenomenon.

The failure to maintain high levels of this behavior during

negative automaintenance has also been demonstrated in previous research with a variety of species. The negative response-reinforcer contingency causes a significant suppression of key peck acquisition and asymptotic performance relative to autoshaping. This suppression demonstrates that both stimulus and response-reinforcer relations exert powerful and nearly equal control of this type of behavior. The behavior and performance of individuals during training on this condition changed more erratically and required more sessions to stabilize than during autoshaping. These species appear to have no stereotyped reaction to negative response-reinforcer contingencies.

Changes in key pecking after acquisition. Each species displayed systematic changes in the force and location of key pecking during negative automaintenance after key peck acquisition. These changes and the development of high rates of off-key pecking were similar to the reactions shown by pigeons during negative automaintenance (Wessells 1973, 1974; Barrera 1974; Hursh, et al. 1974; Lucas 1975). Thus, although negative response-reinforcer contingencies affect the location and force of the key pecking response, its topography remains unchanged.

These changes in the dynamics of key pecking demonstrate that despite the highly stereotyped nature of this response pattern there is some flexibility to accomodate the distinctive properties of specific food items. This flexibility also suggests a general tendency to persist in the manipulation of stimuli associated with food.

These reactions to negative automaintenance result in con-

tiguity between behaviors other than key-pecking and reinforcement. The development of high rates of these other behaviors was observed in the current research and previous research with pigeons (Wessells 1973, 1974; Lucas 1975), demonstrating a sensitivity to positive response-reinforcer contingencies.

During negative automaintenance there are three relationships present: a contiguity between the trial stimulus and the reinforcer, an adventitious contiguity between off-key pecking and the reinforcer, and a negative contingency between on-key pecking and the reinforcer. The effects of the negative contingency on key pecking are clear. However, the contiguities also have potent effects on off-key behaviors, which often take the form of the species-typical peck response.

Behavior during the control conditions. The demonstration of systematic behavioral changes during each of the control conditions represents a significant new finding. Previous research did not employ observational techniques and thus it was impossible to analyze behavior during these conditions.

The failure to display high levels of key pecking during each of these conditions supports and extends the comparative generality of previous research. The high levels of key pecking during autoshaping with these species results from the association of the trial stimulus with reinforcement.

The occasional key pecking during these conditions demonstrates that at least some initial key pecking during autoshaping may be

attributed to non-associative reactions to the intermittent stimulus presentations and reinforcement deliveries. This type of reaction may account for much of the individual variability in the rate of key peck acquisition during autoshaping.

Behavior during trial stimulus and reinforcement-alone training. Each species displayed systematic behavioral changes and developed particular behavior patterns during trial stimulus and reinforcement alone training. During trial stimulus alone training, idiosyncratic activity patterns with frequent key orientations and occasional key pecks were observed. During reinforcement alone training activity was concentrated in the reinforcement magazine area and there were frequent magazine orientations and occasional magazine pecks. These behavior patterns were similar to informal descriptions of the behavior of pigeons during these conditions (Brown and Jenkins 1968; Endberg et al 1972, Bilbrey and Winokur 1973; Gamzu and Williams 1973; Wasserman and Molina 1975). These behavior patterns may be the characteristic reactions to intermittent stimulus presentations and reinforcement deliveries of most avian species. The feeding response systems of most avian species probably includes a tendency to attend to intermittent stimuli and to remain near the source of intermittent reinforcement deliveries.

These behavior patterns are similar to those shown during autoshaping, prior to key peck acquisition. At least some of the initial behavioral changes during autoshaping with these species can be attributed to non-associative reactions to the intermittent stimulus presentations and reinforcement deliveries. These reactions may, in

fact, set the occasion for learning about the relationship of the stimulus to reinforcement. That is, without initial orientation to the stimulus and proximity to the source of reinforcement, there could be no opportunity for the establishment of the stimulus-reinforcer relationship.

These behavior patterns probably facilitate the process of learning about the stimuli associated with food in nature. The attention and reactivity to intermittent stimuli would facilitate the capture and consumption of food items when first encountered. The tendency to remain near the source of food items would facilitate the detection of stimuli preceeding the arrival of the food items. These patterns probably represent evolved behavioral reactions to situations commonly encountered during feeding. The stimuli which elicit orientation are probably representative of a wide variety of food resources which these species depend on in the natural environment. The concentration of feeding behavior in a particular area after food is initially encountered probably increases the likelihood of obtaining more of that food resource.

Behavior during random trial stimulus reinforcement training. Each species also displayed systematic behavioral changes and developed a particular behavior pattern during random trial stimulus-reinforcement training. This pattern consisted of limited activity and random orientation around the cubicle. This behavior pattern is also similar to informal descriptions of the behavior of pigeons during this condition (Gamzu and Williams 1979; Bilbrey and Winokur 1073; Wasserman et al 1974; Tomie 1976). This behavioral pattern may

be the characteristic reaction of most avian species to random stimulus presentations and reinforcement deliveries. The unusual random contingency in this condition probably does not occur during feeding in the natural environment, Thus, it seems unlikely that this behavioral pattern represents an evolved reaction to this type of contingency. Instead, this behavior pattern probably represents a disruption of the typical reactions to intermittent stimulus presentations and reinforcement deliveries. This disruption probably consists of extinction of the normal behavioral reactions to these events, resulting in the observed behavior patterns.

Behavior during the transfer conditions. The demonstration of systematic transfer effects during autoshaping and negative automaintenance also represents a significant new finding. Previous research resulted in contradictory findings and suffered from numerous procedural difficulties. In addition, no single study systematically varied and compared the effects of all the types of previous experience employed in the current research.

The effect of autoshaping on negative automaintenance. Each species displayed systematic transfer effects during negative automaintenance after extensive autoshaping experience. The subjects in this group displayed lower levels of key pecking, smaller individual differences, and stabilized more quickly than naive subjects. Barrera (1974) reported that naive pigeons displayed more sustained key pecking during negative automaintenance than autoshaping experienced subjects. The control of pecking behavior in these species by nega-

tive response-reinforced relations is affected by the subject's prior experience.

Autoshaping experience reduced the subjects' resistance to the extinction or counter-conditioning occurring during negative automaintenance. This transfer effect is similar to the "partial reinforcement effect" (Skinner 1938), in which consistent reinforcement of an operant response results in less resistance to extinction than partial reinforcement. Thus, the transfer effect during negative automaintenance may have been caused by the consistent positive response-reinforcement contingency during autoshaping.

The effect of negative automaintenance on autoshaping. Each species also displayed systematic transfer effects during autoshaping after extensive negative automaintenance experience. The subjects in this group displayed little behavioral change during autoshaping and key peck performance was eliminated or suppressed compared to naive subjects. Browne et al. (1974) found that negative automaintenance experienced pigeons failed to acquire key pecking during autoshaping, but this may have been caused by the variable trial procedures employed. The behavioral changes caused by the negative response-reinforcer contingency during negative automaintenance were relatively permanent. The normal control over pecking behavior by stimulus-reinforcer relations was affected by the subjects' prior experience.

Negative automaintenance experience reduced the subjects' reactivity to the strengthening effects of both stimulus- and response-reinforcer relations. The level of key pecking was much lower than during autoshaping with naive subjects. Some key pecking

did occur, demonstrating at least a residual effect of the stimulus-reinforcer relationship. This key pecking also established response-reinforcer contiguities but these seemed to also have little effect on the strength of the behavior. The fixed trial procedures may have reduced the normal effects of the response-reinforcer contiguities. The subjects received no immediate feedback concerning the effect of key pecking during either autoshaping or negative automaintenance. This delay of reponse outcome information had little effect during autoshaping because the subjects generally key pecked repeatedly during this interval and there was close temporal contiguity between pecking and reinforcement delivery. During negative automaintenance, if the subjects pecked, it was at the onset of the trial stimulus and there was a relatively long delay before reinforcement delivery. Frequently, off-key pecking and other behaviors occurred during this interval. This established the response-reinforcer contiguity between these behaviors and reinforcement, and eliminated the contiguity between key pecking and reinforcement.

The effect of the control conditions on autoshaping. Each species also displayed systematic transfer effects during autoshaping after extensive experience in each of the control conditions. Each control condition affected different aspects of the behavior of the subjects during autoshaping compared to naive subjects. The normal behavioral reactions during autoshaping were reduced in some cases but they were facilitated in others. The behavioral changes caused by the intermittent trial stimulus presentations and/or reinforcement deliveries during these conditions were relatively transient.

Overall, these transfer effects support the conclusion that previous experience affects the control by stimulus-reinforcer relations over pecking behavior in these species.

During autoshaping following trial stimulus alone training, the subjects displayed differences in the rate of behavioral change and key peck acquisition, in key pecking performance and in the rate of approach to behavioral stability compared to naive subjects. Previous research with pigeons consistently found no transfer effects during autoshaping from this training (Brown and Jenkins 1968; Bilbrey and Winokur 1973; Gamzu and Williams 1973; Wassermann et al. 1974; Wasserman and Molina 1975). This difference may reflect species differences or may be related to procedural differences. A number of steps were taken in the current research to overcome weaknesses in the previous studies. These steps included the use of sensitive acquisition measures, the comparison of naive and trial stimulus alone experienced subjects, and control of the pre-exposure experience and stability during autoshaping. In the current research the pattern of behavioral changes during autoshaping was unaffected by this experience. The rate of these behavioral changes and key pecking performance was changed, however.

During autoshaping following reinforcement alone training, the subjects displayed differences in the rate and patterns of behavioral change and key peck acquisition, and in key pecking performance or the stable behavior pattern compared to naive subjects. Previous research with pigeons found a retardation of key peck acquisition or a suppression of key peck performance during autoshaping following this

training (Endberg et al. 1972; Gamzu et al. 1973). In the current research, the transfer effects from this training are consistent with those in previous research although more extensive. As previously discussed, this may reflect species differencies or may be related to procedural differences. In the current research most aspects of the normal reactivity to stimulus-reinforcer relations were affected by this experience.

During autoshaping following random trial stimulus-reinforcement training the subjects displayed larger individual differences, and a disruption of the rate and pattern of key peck acquisition, key pecking performance, and the stable behavior pattern compared to naive subjects. Previous research with pigeons found a substantial retardation of key peck acquisition and suppression of asymptotic key peck performance during autoshaping following this training (Gamzu and Williams 1971; Bilbrey and Winokur 1973; Tomie 1976). The transfer effects from this training in the current research are consistent with, but more extensive than, those in previous research. As previously discussed, this may reflect species or procedural differences. In the current research, most aspects of the normal reactivity to stimulus-reinforcer relations were affected by this experience.

Interspecific Behavioral Differences

Summary of the major result. The species in the study displayed major behavioral differences in the following areas:

1. The level of key peck acquisition and asymptotic performance

during autoshaping, negative automaintenance, and trial stimulus alone training.

2. The topography of key pecking behavior during each condition.
3. The patterns of behavioral changes and the stable behavior patterns displayed during each condition.
4. The effects of previous experience during autoshaping and negative automaintenance.

The demonstration of species differences in these areas represents an important new finding. Most previous comparative research has employed only a single species and relied on post hoc comparisons with other species. This approach is invalid, however, because procedural differences confound the interpretation of observed species differences. In the only study employing more than one species, Powell and Kelly (1976) failed to use naive subjects to compare all species under the same conditions.

Species differences and adaptive specializations. Blue jays, robins and starlings show several distinctive behavioral specializations for feeding. The species differences observed during the current study are probably the result of these evolved species differences. If this is true, there should be a clear relationship between the behavioral patterns observed in this study and the adaptive specializations of each species.

The blue jay.

Distinctive reactions. The blue jays displayed distinctive reactions during each of the conditions employed in this experiment.

These data suggest several unique characteristics of the blue jays' feeding response system, compared with those of the robins and starlings.

Of the three species, the blue jays were the most sensitive to both stimulus-reinforcer relationships and negative response-reinforcer contingencies, while also being the least sensitive to positive response-reinforcer relations. Although they were the first species to begin pecking during auto-shaping, they showed the lowest levels of pecking during both negative automaintenance and at asymptote during autoshaping.

The blue jays also displayed the greatest response flexibility in food manipulation. While the other two species each used only one stereotyped response topography, the blue jays showed two distinctly different topographies in their pecking behavior.

The blue jays appeared to be the least reactive of these three species to the three control conditions. They consistently showed low levels of behavior during trial stimulus alone testing, reinforcement alone testing and random presentations of the trial stimulus and reinforcement.

Overall, the blue jays also showed the largest transfer effects throughout the study. They showed the largest facilitation effects during negative automaintenance following autoshaping, large suppression effects during autoshaping following negative automaintenance, and large facilitation effects following both trial stimulus alone and reinforcement alone training.

The descriptions of the habits and species-typical behavior

patterns of the blue jay in nature provide a functional basis for interpreting several of the suggested characteristics of the feeding response system of this species. Overall, the blue jay may be considered an omnivore, consuming both animal and vegetable matter. The exact prey items and food resources consumed varies considerably with the season and the availability of specific food resources (Bent 1946). In fact, exploration of novel and unusual food resources such as bird feeders and harvest corn decorations is characteristic of this species. This type of feeding adaptation probably requires a lasting potential for rapid stimulus-reinforcer learning and a broad flexibility in the range of stimuli which may be associated with food consumption. This adaptation probably forms the basis for the strong sensitivity to stimulus-reinforcer relations shown by the blue jays during autoshaping.

The reliance on this type of learning as an adaptive pattern is also demonstrated by the developmental cycle of this species. The young blue jays are totally dependent on the adults to provide food for several months after hatching and remain a subordinate member of the family group for a period of a year or more (Hardy 1961). During this time, but especially early in development, the young blue jays exhibit "begging" displays and accept food obtained by the adults, prior to group feeding. This pattern provides the young birds with repeated opportunities to learn about the specific stimuli associated with food consumption. These learning opportunities consist of the brief presentations to the young bird of the food item by the adult before it is consumed. The presentation of the food item probably facilitates

the reactivity of the young bird to these stimuli and the potential for learning about the relationship of these stimuli to food reinforcement in the future. This adaptation probably also forms the basis for the increases in the species typical foraging behavior pattern during autoshaping and reinforcement alone training. The facilitation of later stimulus-reinforcer learning observed following trial stimulus and reinforcement alone training is also probably based on this adaptation.

The typical feeding behavior pattern of this species might best be described as "hunting" rather than "foraging." That is, they rarely locate food items by randomly foraging on the ground for extended periods of time. Instead, they seem to systematically hunt for specific prey or other resources which are abundant at the time. These items are often found directly on or near trees. Trips to the ground to obtain these items are often very brief, the birds show great wariness, and a strong reactivity to any stimulus which might signal danger (Hardy 1961). An additional typical characteristic, as previously mentioned, is for blue jays to take frequent advantage of novel and unusual food resources. They show great stealth in obtaining food from this type of source and a tendency to fly away at the slightest interruption (Bent 1946). These behavior patterns and tendencies support the conclusion that this species relies heavily on the detection and recognition of distal stimuli associated with food consumption. In addition, this "hunting" adaptation probably forms the basis for the species-typical behavior pattern shown during autoshaping and a number of other conditions employed in the current

research. The strong sensitivity to negative response-reinforcer contingencies, and the suppression of later stimulus-reinforcer learning by experience with this type of contingency, is also probably based on this adaptive pattern.

Finally, Hardy (1961) described the development of a variety of unique response patterns used in food manipulation by blue jays as self-feeding is initiated. One pattern frequently employed to open seeds and nuts consisted of clutching the food object with the feet, usually while perching and "hammering" with the beak by locking the neck and pecking downward from an upright position. Jones and Kamil (1973) found that blue jays in the laboratory also showed a strong tendency to manipulate available objects employing a variety of specific topographical patterns. The two pecking response topographies shown by this species during all the conditions employed in the study are probably also based on these adaptive response patterns.

The robin.

Distinctive reactions. The robins also displayed distinctive reactions during each of the conditions employed in this experiment. These data suggest several unique characteristics of the robins' feeding response system, compared with those of the blue jays and starlings.

Of the three species the robins were intermediate in sensitivity to both stimulus-reinforcer and positive response-reinforcer relationships, while also being the least sensitive to negative response-reinforcer contingencies. They were the second species to

begin key pecking during autoshaping and showed intermediate levels of key pecking during both negative automaintenance and at asymptote during autoshaping. They were, however, the only species to show reliable sustained key pecking during stability on negative automaintenance.

The robins displayed limited response flexibility for food manipulation. While one of the other species used two stereotyped response topographies, the robins and the starlings showed only one distinctive topography each. The response topographies of these species were distinctly different. The robin showed lower rates and additional behaviors in the overall pattern including orientations and activity.

The robins appeared to be the most reactive of these three species and consistently showed high levels of behavior and the highest level of key pecking during trial stimulus alone training. They appeared to be intermediate in reactivity of these three species and consistently showed intermediate levels of behavior during reinforcement alone training. They appeared to be the least reactive, however, of these species and consistently showed stable behavior during random trial stimulus alone training.

Overall, the robins also showed the smallest transfer effects throughout the study. They showed the smallest suppression effects on performance during negative automaintenance following autoshaping, but failed to maintain key pecking during stability. They showed the smallest and most transient suppression effects during autoshaping following negative automaintenance and no transfer effects following

any of the control conditions.

Adaptive specializations. The descriptions of the habits and species-typical behavior patterns of the robin in nature provide a functional basis for interpreting several of the suggested characteristics of the feeding response system of this species. Overall, the robin may be considered somewhat of a specialist, consuming both animal and vegetable matter in nearly equal quantities. The specific prey items and food resources (Eiserer 1976) consumed varies considerably with the season and local conditions. There is not a constant variation in the particular food resource consumed however, as robins often concentrate on food items which are abundant for relatively short periods of time. This type of feeding adaptation probably requires a lasting potential for stimulus-reinforcer learning and some flexibility in the range of stimuli which may be associated with food consumption. The intermediate sensitivity to stimulus-reinforcer relations shown by the robins during autoshaping is probably based on this adaptation.

The developmental cycle of this species also demonstrates that they may rely on this learning process and additional mechanisms for food recognition. The young robins are totally dependent on the adults to provide food, primarily animal matter, only for the first few weeks after hatching. They grow rapidly and fledge early, but remain in the adults' territory. They forage for food, again primarily animal matter, with the adults providing progressively smaller portions. After several weeks, the young birds become proficient at independently obtaining prey and leave the territory, forming large

adolescent flocks which continue to feed on this resource (Eiserer 1976).

This pattern provides the young for a short time with limited opportunities to learn about the stimuli associated with food consumption. These learning opportunities consist of very brief and infrequent presentations of the food item by the adult before it is consumed. This mechanism probably facilitates somewhat the reactivity to these stimuli but not the potential for learning about the relationship of these stimuli to food reinforcement in the future. This adaptation probably also forms the basis for the increase in the species typical foraging behavior pattern shown during autoshaping and during trial stimulus and reinforcement training. The stability of later stimulus-reinforcer learning observed following all the control conditions is also probably based on this adaptation. This pattern also provides the young birds with an opportunity to observe and social facilitation of the species typical foraging pattern. This probably facilitates the release of this pattern later during flock feeding.

The behavior of the robins in the study suggests several additional mechanisms which may aid in the process of recognition and consuming food. The intermediate sensitivity of the robins to positive response-reinforcer relations suggests a limited potential in this species for learning based on a displacement of the terminal pecking response from the stimuli. In nature this might consist of learning to displace the terminal pecking response from the prey itself to a different place due to a specific reaction by the prey

when attacked. The predominance of both this type of learning and stimulus-reinforcer learning over learning based on negative response-reinforcer contingencies suggests a potentially adaptive tendency to perseverate in emitting the terminal pecking response despite repeated failures. The low levels of non-associative key pecking during trial stimulus alone training suggests an innate tendency to peck at brief, intermittent, visual stimuli. The stability of the reactivity to stimulus-reinforcer relations during each of the transfer conditions and the maintenance of key pecking during negative automaintenance also supports this conclusion.

The robin frequently displays a unique feeding behavior pattern when feeding on animal prey, especially earthworms. This pattern is employed by the adults obtaining food for the young birds both prior to and after fledging during family feeding. The young birds also engage in this behavior during flock feeding (Eiserer 1976). This pattern might best be described as a combination of "foraging" and "hunting." That is, they locate food items by foraging on the ground for extended periods of time. They seem to systematically hunt for specific prey or other resources which are abundant at the time. They prefer open fields and lawns located near trees and wooded areas and cover wide areas in zig-zag patterns. Heppner (1965) found that they alternated short straight runs with pauses to look from side to side at the ground. Occasionally, they hop or fly short distances to pounce on a worm tail or burrow. They often showed repeated attempts to capture these and other prey and food resources. These behavior patterns and tendencies support the conclusion that this species may

rely both on an innate reaction to stimuli characteristic of certain typical prey items and on the detection and recognition of distal stimuli associated with food consumption. In addition, this "hunting-foraging" adaptation probably forms the basis for the species typical behavior pattern shown during autoshaping and a number of other conditions employed in the current research. The limited sensitivity to the negative response-reinforcer contingency and the lack of transfer effects of later stimulus-reinforcer learning from this type of experience is also probably based on this adaptive pattern.

Finally, Eiserer (1976) found that the young robins depend primarily on this feeding behavior pattern during flock feeding and that adults utilize this pattern whenever possible. Heppner (1965) found that adults utilize this pattern to obtain 20% or more of their diet. The limited response flexibility shown by this species during all the conditions employed in the current research is probably also based on this specialization adaptive response pattern.

The starling.

Distinctive reactions. The starlings displayed distinctive reactions during each of the conditions employed in this experiment. These data suggest several unique characteristics of the starlings' feeding response system, compared with those of the blue jays and robins.

Of the three species, the starlings were the least sensitive to stimulus-reinforcer relationships and intermediate insensitivity to negative response-reinforcer contingencies, while also being the most sensitive to positive response-reinforcer relations. Although they

were the last species to begin pecking during autoshaping, they showed the highest levels of pecking during both negative automaintenance and at asymptote during autoshaping.

The starlings also displayed the most limited response flexibility for food manipulation. While the robins also used only one stereotyped response topography, the blue jays showed two distinctly different topographies in their pecking behavior. The starlings showed virtually no activity or other behaviors during key pecking. They engaged in this behavior at incredibly high rates with virtually no variability within or between individuals.

The starlings appeared to be intermediate in reactivity of these three species and consistently showed intermediate levels of behavior during trial stimulus alone training. They appeared to be the most reactive of these species and consistently showed the highest levels of behavior during reinforcement alone training. They appeared to be intermediate in reactivity and showed large individual differences in behavior during random trial stimulus-reinforcement training.

Overall, the starlings also showed the largest transfer effects throughout the study. They showed the largest suppression effects during negative automaintenance following autoshaping, intermediate suppression effects during autoshaping following negative automaintenance, and large suppression effects following both trial stimulus alone and reinforcement alone training.

Adaptive specializations. The descriptions of the habits and species-typical behavior patterns of the starling in nature provide a functional basis for interpreting several of the suggested

characteristics of the feeding response system of this species. Overall, the starling may be considered an omnivore, consuming both animal and vegetable matter in widely varying proportions depending on the season and the availability of specific food resources (Kalmbach and Gabrielson 1921, Lindsey 1939, Dunnett 1955, and Russel 1971). The starling has been characterized as a highly adaptable species as demonstrated by their rapid expansion across the North American continent since their introduction (Bent 1964). This type of feeding adaptation and general capacity for adaptation to new environs requires a lasting potential for stimulus-reinforcer learning and some flexibility in the range of stimuli which may be associated with food consumption. The low sensitivity to stimulus-reinforcer relations shown by the starlings during autoshaping is probably based on this adaptation.

The developmental cycle of the starling demonstrates that this species may rely on this learning process and additional mechanisms for food recognition. The young starlings are totally dependent on the adults to provide food, primarily animal matter, only for the first two to three weeks after hatching. They develop rapidly and fledge early, but remain with the adults for several weeks. They forage for food with both parents and in small flocks, again primarily for animal matter, with the adults providing relatively little assistance in obtaining food. Later, as the adults prepare for the next brood, the young birds leave the parents, form large adolescent flocks which continue to forage primarily on animal matter until the fall migration (Bent 1964).

This pattern provides the young with very limited opportunities to learn about the stimuli associated with food consumption. These learning opportunities consist of brief presentations to the young bird before fledging of the food item by the adult before it is consumed. This mechanism probably facilitates somewhat the reactivity to these stimuli and certain aspects of this experience may increase the potential for learning about the relationship of these stimuli to food reinforcements in the future. This adaptation probably also forms the basis for the increase in the species typical foraging behavior pattern during autoshaping and trial stimulus and reinforcement alone training. The facilitation of later stimulus-reinforcer learning observed following reinforcement alone training is also probably based on this adaptation. The suppression of later stimulus-reinforcer learning observed following trial stimulus alone training and random trial stimulus-reinforcement training suggests, however, that these experiences disrupt this learning mechanism. This developmental pattern also provides the young birds with repeated social facilitation of the species typical foraging pattern. This probably greatly facilitates the release of this pattern later during flock feeding.

The current research suggests several additional mechanisms which may aid the starling in the process of recognition and obtaining food. The strong sensitivity of the starlings in the current research to adventitious response-reinforcer contingencies suggests a strong potential in this species for learning based on a displacement of the terminal pecking response from the stimuli. In nature, this might

consist of learning to utilize the terminal pecking response to manipulate an object or the substrate to reveal or dislodge potential prey or other food resources. The predominance of this type of learning over learning based on negative response-reinforcer contingencies suggests a highly adaptive tendency to perseverate in emitting the terminal pecking response despite a large number of failures. The nearly equal control exerted by learning based on stimulus-reinforcer relations and negative response-reinforcer contingencies suggests a potentially adaptive tendency to stop emitting the terminal pecking response in the presence of a particular stimulus after repeated failures.

The starling relies primarily on a unique foraging behavior pattern and response pattern regardless of the prey or food resources being consumed. They display this pattern during feeding with the parents shortly after fledging and during later flock feeding. This pattern is especially effective in locating or "flushing" insects and other prey hidden in the grass or near the surface of the soil, but also reveals vegetable matter (Bent 1964). This pattern might best be described as "foraging," in that they locate food items by probing the grass and soil for very extended periods of time. Large flocks spread evenly over an area and move in an orderly and coordinated manner, obtaining whatever food resources are available (Lorenz 1949). They prefer open fields and lawns and avoid heavily wooded areas, but often adapt to noisy, dangerous environments near man such as garbage dumps and median strips. Regardless of the area, the individuals of the flock forage by moving in zig-zag patterns

constantly probing the substrate and rapidly consuming food items as encountered. They show repeated attempts to capture prey if the first attempt fails and manipulate small objects which are encountered. The entire flock is easily startled during feeding and fly off briefly when interrupted but generally return immediately if the source of the interruption is removed (Bent 1964). These behavior patterns and tendencies support the conclusion that this species does not rely heavily on the detection and recognition of distal stimuli associated with food consumption. Rather, they seem to depend more on a rapid reaction to various types of stimuli encountered and on the constant emission of the response pattern which functions to uncover these types of stimuli. This adaptation is probably also aided by a potential for rapid response-reinforcer learning to manipulate stimuli encountered in a particular way so as to obtain food. This adaptation probably also forms the basis for the species typical behavior pattern shown during autoshaping and a number of other conditions employed in the current research. The sensitivity to negative response-reinforcer contingencies and the species typical behavior pattern shown during this training are probably also based on this adaptive pattern.

Finally, Dunnett (1955) described the unique "gaping" response pattern employed by this species during virtually all feeding activities. Beecher (1951) described a variety of morphological specializations in the location of the eyes and the head musculature of this species which facilitate this response pattern. The very limited response flexibility shown by this species during all the conditions

employed in the current research is probably also based on this adaptive response pattern and morphological specialization.

Theoretical Implications

Two-process learning theory. Brown and Jenkins (1968) recognized that the autoshaping phenomena contradicted many of the accepted principles of the two-process learning theory (Skinner 1938; Kimble 1961; and Rescorla and Solomon 1967). The demonstration of the acquisition and maintenance of key pecking during negative automaintenance by Williams and Williams (1969) provided further evidence of the weakness of this approach.

The extensive research on these phenomena including the current study emphasizes the inadequacy of labeling learning phenomena based on the controlling procedure or the characteristics of the behavior without objective criteria. These phenomena question the "arbitrariness" of key pecking and other typical responses employed in operant situations. These phenomena also question the emphasis on response-reinforcer contingencies in controlling behavior to the exclusion of stimulus-reinforcer relations. Finally, these phenomena question the concept of "shaping" of operant responses and the failure to consider the constraints asserted by species typical characteristics in determining the behavior generated during operant situations.

Hearst and Jenkins (1968) and Williams and Williams (1969) suggested the recognition of a third basic type of behavioral response with unique characteristics and an ontogeny in biological predisposi-

tions or species specific tendencies. Most of the research in this area including the current study support these ideas. Various theorists have pointed out the necessity for a revision in the interpretations and assumptions of two-process learning theory (Hearst and Jenkins 1974; Herrnstein 1976; and Honig and Staddon 1977). Several formal theoretical systems have been proposed (Moore 1971; Hearst and Jenkins 1974; Williams 1977). However, there has been no general consensus on the comprehensiveness and ability of these theories to account for autoshaping and related phenomena.

Biconditional behavior. Williams (1974) proposed the concept of biconditional behavior and the acquired release of fixed action patterns (Woodruff 1974; Woodruff, Morrison, and Williams 1974) to account for these phenomena. This approach stresses a more biological and functional perspective on the analysis of learning and attempts to integrate concepts from both ethology and traditional learning theories.

An important assumption of this theory is that individual behaviors may be conditioned by both standard conditioning procedures (operant and respondent). Furthermore, within either of these procedures it is impossible to entirely eliminate the influence of the other type of relationship. Williams (1974) also recognized that the behaviors under study are part of the subjects' species typical repertoire. Thus, the data has relevance to the subjects' normal behavior and adaptation in the natural environment. He pointed out several parallels between the research on classical conditioning and

autoshaping which support the view that a critical aspect of both the trial stimulus and conditioned stimulus is its informativeness, based on its relationship to the reinforcement.

The mechanism proposed to account for this type of learning is the same as that responsible for the natural acquisition of ingestive patterns of behavior to new reinforcers during development. That is, during development many species show only tentative or partial responses to normal reinforcers such as food or water and may show similar responses to entirely inappropriate objects such as sand and pebbles. After reinforcement is ingested, however, the response to that stimulus rapidly changes and the entire species typical response pattern occurs. Responses to stimuli which do not lead to reinforcement ingestion are quickly eliminated. The response-reinforcer relationship is essential as it sets the occasion for the stimulus-reinforcement learning but the animal learns which stimuli to respond to rather than how to respond.

In the autoshaping procedure the stimuli associated with reinforcement already elicit or release the appropriate fixed action pattern (FAP) and the trial stimulus comes to release the same behaviors through associative conditioning. These FAPs however, are not predictable from knowledge of the characteristics of the trial stimulus and reinforcement alone but require knowledge of the species and its normal behavior. Williams (1974) pointed out the similarity of the characteristics and properties of these responses and those commonly elicited by electrical stimulation of the brain, thus indicating a central rather than a peripheral organization and control

of these responses. He also argued against the stimulus substitution explanation (Moore 1971) of this type of respondent conditioning because the reinforcing stimulus and unconditioned response to this event may be quite different from the conditioned stimulus and response. That is, in the autoshaping situation the grain and the peck have often been assumed to be the unconditioned stimuli and response but as discussed earlier the association between these events was conditioned during development.

Williams (1974) proposed that the actual unconditioned stimulus in this situation is the stimulus of grain in the throat and the unconditioned response is swallowing. Thus, pecking and other responses to distal stimuli associated with reinforcement are considered to be innate and species typical but their association is conditioned via the spatial-temporal contiguity with the occurrence of more proximal unconditioned stimuli and responses. These responses function as Lorenz's (1950) appetitive behaviors to insure contact with and consumption of reinforcers via the occurrence of unconditioned or consummatory behaviors.

Williams (1974) also emphasized the complex and multi-component nature of these appetitive response systems and that species may differ substantially in their reactions to the same stimuli- and response-reinforcer contingencies due to evolved differences in these systems. In addition, within the same species the appetitive response systems associated with different reinforcers may differ in complexity, characteristics, etc., depending on the nature of the reinforcement and the stimuli associated with it.

This theory is a much more thorough and comprehensive approach to the problem of accounting for autoshaping and related phenomena. It is an innovative position which proposes and provides substantial support for a radical revision of the currently accepted theories of classical and operant conditioning. The acceptance and utilization of ethological concepts and principles provides a much broader data base of research upon which to further develop this theory. These data and concepts are also consistent with Williams's (1974) formulation and complement the laboratory research. This approach breaks from traditional learning theories in attempting a functional analysis of laboratory research stressing the relevance of the animals' species typical repertoire.

This emphasis allows specific predictions to be made concerning the behaviors to be expected and the characteristics of performance of a particular species during autoshaping and other conditioning tasks based on the observational data on the behavior of the species in the natural environment. These data provide information on the relevance and function of these behaviors in the animals' adaptation, and the use of strictly controlled and technologically sophisticated procedures in the laboratory provides a substantial improvement in the researcher's ability to determine the exact characteristics and properties of these behaviors.

This theory also allows specific predictions to be made concerning the outcome of various potential conditioning and control procedures with only those in which a correlational relationship between the TS and reinforcement supporting learning.

The mechanism proposed to account for this type of learning is also well supported by the ethological data and theory on early learning and development (Hinde 1971) and is consistent with mechanisms proposed to account for Imprinting (Bateson 1971, Hess 1973; Hoffman and Ratner 1973) and the ontogeny of initial feeding responses in young fowl (Hogan 1971, 1973a,b, 1975).

This theory accounts very well for the results of the current research and these data provide support for a number of critical aspects of this formulation. The current research and previous unpublished work with the species employed indicates that key pecking behavior may be readily controlled by both operant and respondent procedures. The behavior conditioned by both these procedures are part of the subjects' species typical repertoire of appetitive behaviors associated with the reinforcer. There was a predictive relationship between the behavior and performance observed during the current research and generalizations concerning the adaptation and behavior of these species in the natural environment. These species also displayed sensitivity to both stimulus- and response-reinforcer relationships.

The acquisition or suppression of key pecking behaviors during autoshaping and negative automaintenance, respectively, was similar to that displayed by these species when learning about new food and non-food items encountered in the natural environment. The highly stereotyped species typical nature of the key pecking response topography shown by the subjects in the current research provide strong support that the learning involved during autoshaping consists

of learning which stimuli to respond to rather than how to respond. Close analysis of the behavior patterns shown during key pecking and consumption of the reinforcers provides support for the position that the subjects utilized the same response topography in manipulating the two stimuli and that both are conditioned rather than unconditioned stimuli.

Further evidence for this position is provided by the gradual decrease in latency to retrieve the reinforcer and the gradual emergence of full appetitive and consummatory patterns of behavior in response to the reinforcement delivery during magazine training. The responses conditioned in the current research were complex and multi-component patterns similar in many respects to the appetitive species-typical response patterns displayed by each species in nature. In addition, the species displayed substantial differences in their reactions to the stimuli and response-reinforcer contingencies employed in the current research despite strict standardization and control of these variables.

Future research. The question of whether autoshaping represents a generalized or a specialized learning adaptation in avian and other species is crucial to determining the relevance and broad theoretical implications of autoshaping research. Future research should compare autoshaping in closely related species with different specialized feeding patterns. This type of comparative analysis will allow assessment of both the generality of autoshaping and the extent of variation resulting from phylogenetic relationships and from

feeding specializations.

Assessment of the validity of conceptualizing autoshaping as a process controlling a complex sequence of behavior rather than simply effecting the terminal response of this chain is also crucial to the development of a comprehensive understanding of this phenomenon. This may be accomplished by the comparative analysis of behavior changes during autoshaping with a wide variety of species. Representative species of large related groups should be selected for this research to assess the generality of this pattern during acquisition. In addition, species showing other specialized behaviors as part of their normal feeding behavior pattern should be selected to determine whether these behaviors also occur during autoshaping. Analysis of early behavioral changes during autoshaping may be used to detect initial stages of key peck acquisition with species which show a very slow rate of key peck acquisition and might help to determine why a particular species failed to autoshape. Special procedures might be employed to facilitate these early changes in behavior and subsequent autoshaping in species which fail or show very poor acquisition.

The current formulation represents a functional interpretation of the behavior observed during autoshaping and in other artificial laboratory situations. It suggests a strong predictive relationship between the behavior patterns which have evolved to facilitate adaptation to the problems of survival in the natural environment and the behavior displayed inactions to experimental problems in the laboratory. Confirmation of this approach may be accomplished only by

detailed analysis of the species typical foraging and feeding behavior patterns shown by a wide variety of species in the natural environment and identification of the characteristics of the types of food resources associated with each of these behavior patterns. Laboratory research could then determine whether variation in the type of reinforcer employed causes changes in the behavior pattern shown by the subjects.

Another interesting area of research might be the development of food recognition in a variety of species and determination of the mechanisms by which stimuli are associated with reinforcement in the natural environment. Species may show a similar reaction to the stimulus-reinforcer relationships established during autoshaping but this process could be accomplished by a variety of mechanisms in the natural environment, including parental feeding and social facilitation during flock feeding. Autoshaping may also be a convenient laboratory tool for the detailed analysis of species typical feeding patterns and the establishment of phylogenetic relationships between closely related but highly specialized species.

There are a variety of potential types of reactions a particular species might show to positive and negative stimulus- and response-reinforcer contingencies. The type of reaction would depend on the characteristics of the type of food resources the species normally depends on and the most efficient strategy for obtaining these food items. For example, species which rarely encounter failure when foraging may very rapidly stop responding during negative automaintenance, but species which frequently encounter failure may

show very persistent behavior. Thus, it may be advantageous for one species to depend primarily on stimulus-reinforcer relationships regardless of negative response-reinforcer contingencies but this may be highly inappropriate for another species feeding on a different type of food item. This formulation may be experimentally tested by conducting a detailed analysis of the types of contingencies occurring in nature and the extent of control over normal feeding behavior exerted by these contingencies in a wide variety of species. Species should be selected which represent each potential type of adaptation. Species should also be selected which encounter different types of contingencies during feeding and which show different reactions to these contingencies. Performance of these species during autoshaping, negative automaintenance and various control conditions should then be assessed to determine whether each species reacts to the contingencies in this situation as predicted by the behavior in the natural environment.

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APPENDIX

Tables 2-11. Key peck acquisition during Stage I in each group and during Stage II-Autoshaping in Groups II-V is indexed in Milestone Analysis Tables 2 and 4-11. These tables display the number of trials and sessions required to attain successive levels of key pecking. Key peck reduction during Stage II-Negative automaintenance in Group I is indexed in Table 3 which displays the number of trials and sessions required for each subject to reduce key pecking to successively lower levels. All these tables show the highest rates of key pecking and the highest percentage of trials with a key peck during a session, the session during which these levels were attained, and the number of sessions required to attain behavioral stability.

Table 2. Individual and species mean number of trials and sessions required to condition successive stages of key peck acquisition, the highest rates of key pecking and highest percentages of trials with a key peck, and the number of sessions to behavioral stability for the blue jays, robins, and starlings in Group I during Stage I-Autoshaping.

Species	Bluejay				Robin				Starling			
S #	307	131	316	X	381	375	372	X	398	394	399	X
Tr 1st Peck	109	40	5	51.3	37	56	102	65	417	55	118	196.7
Session	3	1	1	1.6	1	2	3	2	9	2	3	4.7
5 Trs with Peck	356	158	14	176	167	356	306	276	556	280	434	423
Session	8	4	1	4.3	4	8	7	6.3	12	6	9	9
10 Trs with Peck	361	330	161	284	270	361	311	314	561	329	461	450
Session	8	7	4	6.3	6	8	7	7	12	7	10	9.7
Sessions to 100% Trs with Peck	11	13	-	12	14	8	18	13.3	13	8	10	10.3
Highest Peck Rate/Min	72.4	26.2	32.8	43.8	93.6	106	58.2	85.9	154	200	163	172
Session	12	13	4	9.7	14	19	22	18.3	22	20	16	19.3
Highest % Trs with Peck	100	100	92	97.3	100	100	100	100	100	100	100	100
Session	11	13	4	9.3	14	8	18	13.3	13	8	10	10.3
Sessions to Stability	18	23	19	20	23	22	22	22.3	23	20	22	21.7

Table 3. Individual and species mean number of trials and sessions required to condition successive stages of key peck reduction, the highest rates of key pecking and highest percentages of trials with a key peck, and the number of sessions to behavioral stability for the blue jays, robins, and starlings in Group I during Stage II-Negative automaintenance.

Species	Bluejay				Robin				Starling			
S #	307	131	316	X	381	375	372	X	398	394	399	X
1st Tr without Peck	33	3	15	17	3	20	12	11.7	29	49	59	45.7
Session	1	1	1	1	1	1	1	1	1	1	2	1.3
5 Trs without Peck	74	23	56	51	74	119	256	150	261	91	118	157
Session	2	1	2	1.7	2	3	6	3.7	6	2	3	3.7
10 Trs without Peck	761	28	76	288	79	148	279	168	299	134	370	268
Session	16	1	2	6.3	2	3	6	3.7	6	3	8	5.7
Sessions to 0 Peck	17	12	[illegible]	12.3	10	9	11	10	13	11	14	12.7
Highest Peck Rate/Min	43.6	13.5	14.7	23.9	37.7	50.8	39.4	42.6	131	149	98.3	126
Session	1	3	1	1.7	1	1	1	1	1	1	1	1
Highest % Trs with Peck	94	84	64	78.7	70	86	90	82	98	96	100	98
Session	12	3	1	5.3	1	1	1	1	1	1	1	1
Sessions to Stability	21	15	12	16	14	16	16	15.3	14	13	16	14.3

Table 4. Individual and species mean number of trials and sessions required to condition successive stages of key peck acquisition, the highest rates of key pecking and highest percentage of trials with a key peck, and the number of sessions to behavioral stability for the blue jays, robins, and starlings in Group II during Stage II-Negative automaintenance.

Species	Bluejay				Robin				Starling			
S #	311	312	303	X	100	370	2	X	388	389	394	X
Tr 1st Peck	55	63	177	98.3	5	11	6	7.3	11	110	10	43.7
Session	2	2	4	2.7	1	1	1	1	1	3	1	1.7
5 Trs with Peck	206	369	-	288	158	406	656	407	560	158	530	416
Session	5	8	-	6.5	4	9	14	9	12	4	11	9
10 Trs with Peck	-	-	-	-	232	-	912	572	611	426	635	557
Session	-	-	-	-	5	-	19	12	13	9	11	11
Sessions to 100% Trs with Peck	-	-	-	-	-	-	-	-	-	-	-	-
Highest Peck Rate/Min	7	2.5	1.9	3.8	15.1	3.4	16.2	11.6	11.4	34.7	17.6	21.2
Session	7	8	12	9	9	22	14	15	13	19	19	17
Highest % Trs with Peck	46	32	16	31.3	92	32	46	56.7	72	98	90	86.7
Session	5	16	12	11	10	22	14	15.3	13	19	19	17
Sessions to Stability	18	23	17	19.3	28	28	26	27.3	23	33	32	29.3

Table 5. Individual and species mean number of trials and sessions required to condition successive stages of key peck acquisition, the highest rates of key pecking and highest percentages of trials with a key peck, and the number of sessions to behavioral stability for the blue jays, robins, and starlings in Group II during Stage II-Autoshaping.

Species	Bluejay				Robin				Starling			
S #	311	312	303	X	100	370	2	X	388	389	397	X
Tr 1st Peck	252	22	76	117	2	12	10	8	-	67	3	35
Session	6	1	2	3	1	1	1	1	-	2	1	2.5
5 Trs with Peck	310	-	-	-	6	106	131	81	-	-	38	-
Session	7	-	-	-	1	3	3	2.4	-	-	1	-
10 Trs with Peck	675	-	-	-	11	117	368	165	-	-	87	-
Session	14	-	-	-	1	3	8	4	-	-	2	-
Sessions to 100% Trs with Peck	-	-	-	-	-	-	-	-	-	-	5	-
Highest Peck Rate/Min	12.9	.4	.71	4.7	25.4	71.5	18.4	38.4	-	.31	48.6	24.5
Session	7	4	7	6	6	15	13	11.3	-	3	7	5
Highest % Trs with Peck	62	6	6	24.7	74	92	92	86	-	6	100	53
Session	14	4	2	6.8	4	8	8	6.7	-	5	5	5
Sessions to Stability	21	11	11	14.3	13	16	13	14	10	13	13	12

Table 6. Individual and species mean number of trials and sessions required to condition successive stages of key peck acquisition, the highest rates of key pecking and highest percentage of trials with a key peck, and the number of sessions to behavioral stability for the blue jays, robins, and starlings in Group III during Stage I-Trial stimulus alone training.

Species	Bluejay			Robin			Starling		
S #	304	314	X	1	287	X	362	390	X
Tr 1st Peck	3	4	3.5	42	20	31	291	-	-
Session	1	1	1	1	1	1	6	-	-
5 Trs with Peck	-	-	-	-	-	-	-	-	-
Session	-	-	-	-	-	-	-	-	-
10 Trs with Peck	-	-	-	-	-	-	-	-	-
Session	-	-	-	-	-	-	-	-	-
Sessions to 100% Trs with Peck	-	-	-	-	-	-	-	-	-
Highest Peck Rate/Min	.3	.89	.6	2.2	1.34	1.77	.1	-	-
Session	1	4	2.5	6	5	5.5	6	-	-
Highest % Trs with Peck	4	4	4	30	12	21	2	-	-
Session	1	4	2.5	6	5	5.5	6	-	-
# Sessions	10	10	10	10	10	10	10	10	10

Table 7. Individual and species mean number of trials and sessions required to condition successive stages of key peck acquisition, the highest rates of key pecking and highest percentages of trials with a key peck, and the number of sessions to behavioral stability for the blue jays, robins, and starlings in Group III during Stage II-Autoshaping.

Species	Bluejay			Robin			Starling		
S #	304	314	X	1	287	X	362	390	X
Tr 1st Peck	21	6	13.5	36	163	99.5	21	-	-
Session	1	1	1	1	4	2.5	1	1	-
5 Trs with Peck	75	98	86.5	59	262	161	-	-	-
Session	2	2	2	2	6	4	-	-	-
10 Trs with Peck	121	113	117	64	361	213	-	-	-
Session	3	3	3	2	8	5	-	-	-
Sessions to 100% Trs with Peck	7	8	7.5	5	12	8.5	-	-	-
Highest Peck Rate/Min	62.9	90.1	76.5	44.9	37.1	41	.3	-	-
Session	8	11	9.5	14	11	12.5	1	-	-
Highest % Trs with Peck	100	100	100	100	100	100	2	-	-
Session	7	8	7.5	5	12	8.5	1	-	-
Sessions to Stability	11	12	11.5	14	13	13.5	13	13	13

Table 8. Individual and species mean number of trials and sessions required to condition successive stages of key peck acquisition, the highest rates of key pecking and highest percentages of trials with a key peck, and the number of sessions to behavioral stability for the blue jays, robins, and starlings in Group IV during Stage I-Reinforcement alone training.

Species	Bluejay			Robin	Starling		
S #	302	313	X	286	80	387	X
Tr 1st Peck	-	457	-	321	-	385	-
Session	-	10	-	7	-	8	-
5 Trs with Peck	-	-	-	-	-	-	-
Session	-	-	-	-	-	.	-
10 Trs with Peck	-	-	-	-	-	-	-
Session	-	-	-	-	-	-	-
Sessions to 100% Trs with Peck	-	-	-	-	-	-	-
Highest Peck Rate/Min	-	.7	-	.16	-	2.46	-
Session	-	10	-	7	-	9	-
Highest % Trs with Peck	-	12	-	4	-	10	-
Session	-	10	-	7	-	8	-
# Sessions	10	10	10	10	10	10	10

Table 9. Individual and species mean number of trials and sessions required to condition successive stages of key peck acquisition, the highest rates of key pecking and highest percentages of trials with a key peck, and the number of sessions to behavioral stability for the blue jays, robins, and starlings in Group IV during Stage II-Autoshaping.

Species	Bluejay			Robin	Starling		
S #	302	313	X	286	80	387	X
Tr 1st Peck	25	4	14.5	53	39	100	69.1
Session	1	1	1	2	1	2	1.5
5 Trs with Peck	85	130	107.5	111	87	115	101
Session	2	3	2.5	3	2	3	2.5
10 Trs with Peck	90	148	119	250	111	145	128
Session	2	3	2.5	5	3	3	3
Sessions to 100% Trs with Peck	4	5	4.5	8	3	4	3.5
Highest Peck Rate/Min	117.7	110.2	114.0	49	169	142	155.5
Session	8	9	8.5	8	12	11	11.5
Highest % Trs with Peck	100	100	100	100	100	100	100
Session	4	5	4.5	8	3	4	3.5
Sessions to Stability	12	11	11.5	12	13	12	12.5

Table 10. Individual and species mean number of trials and sessions required to condition successive stages of key peck acquisition, the highest rates of key pecking and highest percentages of trials with a key peck, and the number of sessions to behavioral stability for the blue jays, robins, and starlings in Group V during Stage I-Random trial stimulus-reinforcement training.

Species	Bluejay			Robin	Starling		
S #	103	112	X	376	4	386	X
Tr 1st Peck	3	-	-	-	-	323	-
Session	1	-	-	-	-	7	-
5 Trs with Peck	15	-	-	-	-	-	-
Session	1	-	-	-	-	-	-
10 Trs with Peck	-	-	-	-	-	-	-
Session	-	-	-	-	-	-	-
Sessions to 100% Trs with Peck	-	-	-	-	-	-	-
Highest Peck Rate/Min	1.67	-	-	-	-	.8	-
Session	1	-	-	-	-	9	-
Highest % Trs with Peck	40	-	-	-	-	6	-
Session	1	-	-	-	-	9	-
# Sessions	10	10	10	10	10	10	10

Table 11. Individual and species mean number of trials and sessions required to condition successive stages of key peck acquisition, the highest rates of key pecking and highest percentages of trials with a key peck, and the number of sessions to behavioral stability for the blue jays, robins, and starlings in Group V during Stage II-Autoshaping.

Species	Bluejay			Robin	Starling		
S #	103	112	X̄	376	4	386	X̄
Tr 1st Peck	102	72	87	68	-	34	-
Session	3	2	2.5	2	-	1	-
5 Trs with Peck	314	158	236	107	-	107	-
Session	7	4	5.5	3	-	3	-
10 Trs with Peck	-	163	-	112	-	161	-
Session	-	4	-	3	-	4	-
Sessions to 100% Trs with Peck	-	7	-	6	-	4	-
Highest Peck Rate/Min	7.36	74.02	40.69	45.92	-	30.02	-
Session	9	7	8	7	-	4	-
Highest % Trs with Peck	48	100	74	100	-	100	-
Session	8	7	7.5	6	-	4	-
Sessions to Stability	12	11	11.5	11	11	11	11